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BOSTON UNIVERSITY

GRADUATE SCHOOL

Thesis

THE USE OF NEW TYPE OR OBJECTIVE TESTS IN PHYSICS

Submitted by

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CHAPTER I

STATEMENT OF THE STUDY

Ever since education began in a formalized way there have been arguments for and against examinations and even today we hear criticisms of the examination both pro and con. There must be some means of measurement however,[1] and in spite of the discussion, examinations continue in use and will continue in use until some other means is devised whereby the results that are attempted now by examinations will be accomplished more efficiently. Unfortunately we cannot eliminate examinations from the school curricula and therefore we must search for an efficient measuring instrument. In general, it will be more fruitful to attempt to better a practice which consensus of opinion still favors before considering the more drastic step of complete elimination.[2] The new thing is to try to set forth a means of constructing and evaluating a test that will serve as a guide to those who wish to use a type of test that is really of more value than the old type.

Since nearly every teacher is familiar with the old type, or essay examination, no attempt will be made to stress this type. This does not imply that the traditional examination does not have its place in measurement.[3] It has distinct advantages which are well known to every teacher.

1. Odell, C. W. Educational Measurement in High School: p. 3
2. Ruch, G. M. The Objective or New Type Examination: p. 9
3. Odell, C. W. Educational Measurement in High School: p. 482-483

The aim of this thesis, however, is to present, in a concise way, material on the so-called new type or objective examinations in physics, stressing those points which will be of value to a teacher who is desirous of using such tests. That the teacher may have a better basis for evaluating a test, informal or standardized, the writer has included discussions on the objectives of a high school physics course; the teacher-made, new type examination; and a criteria for the evaluation of a standardized test. The writer, also, has included a list of all the tests published up to the present time with an attempted evaluation of each one. In this evaluation no attempt has been made to make any suggestions as to what ought to be, but the comparisons have been drawn on the facts as they are, and the individual teacher left to form his own conclusions. In evaluating the tests the writer has (1) set up a criteria and taken up each test in regard to it, (2) made a quantitative evaluation of material covered in tests as compared with a composite study of text books and college board requirements, and (3) made a study of thought and fact questions. With the addition of a great many new tests in physics in recent years the writer felt that there exists a need for some such work. A test by the writer which he has used in a physics class is, also, included in the appendix as a sample of an informal test.

CHAPTER II

THE OBJECTIVES OF A PHYSICS COURSE

The general content of the present-day high school physics course is familiar to anyone who is acquainted with practically any of the current text books. The six major topics, as presented in these texts, are mechanics, heat, magnetism, electricity, sound, and light. These might well be classified as five major topics because magnetism and electricity are often listed under one head. These divisions are the ones that have been used for the past twenty years--or practically as long as we have been teaching physics, as such, in the high school. This traditional pattern originated and probably has been maintained by the requirements of college entrance exemplified by the conditions set down by the college entrance board.

The general outline of the physics courses, in the typical content today, seems to stress memory work of a great many details which have been altogether too briefly developed and explained. With the rapid development of new theories and expansion of knowledge, especially in the field of newer physics, it has been even more meagerly developed and explained. On all sides we hear the complaint that there is too much material presented to be taught in one year of high school physics. A. W. Hurd says: "There is much evidence that the present year's course in physics, common to most schools, has too much content, if previous achievement is to be increased in objective tests now used."[1] The attempt to cover all and slight nothing has lead to a decrease of the interest in physics on the part of high school pupils, which is shown quite clearly by the rapid falling off of the number of pupils electing this subject.

1. Hurd, A. W. Cooperative Experimentation in Materials and Methods in Secondary School Physics 1933: p. 4

There has been recent agitation in Associations of Physics teachers in the East and in the South to allow more than one year for the teaching of the content of the present high school course. There is no question but that the five topics as covered in the high school today, offer far too much material to be covered in one year. To sum up the objections, then, we might say that the fault of the present day system is that the material is a cut and dried, stereotyped mass of unrelated facts that are far too numerous in number to be taught during the course of one year. There is also the additional point that it is not presented in such a way as to arouse interest in the pupils by presenting the problems of high school physics from the point of view of life situations.

"An overwhelming majority of writers who suggest inadequacies in the teaching of high school science agree that the greatest need is a reorganization of content or subject-matter to meet the needs of the pupils enrolled."[1] The present trend toward reorganization had its first start with the report of the Vestal Committee in 1921.[2] Although the list of topics in this report was fundamentally the same as the traditional outline, there are some changes in the way it is presented. There is evidently some attempt made to present the topics of the old order in terms of life situations. Various investigations have been made, showing that the report of the Vestal committee was sound but no real constructive work was attempted until Hurd, in nineteen twenty-nine, published the work that he had been doing for the North Central Association.[3]

1. Hurd, A. W. Cooperative Experimentation in Materials and Methods in Secondary School Physics: 1933 p. 3
2. Vestal, C. L. and others. "Report of the Sub-committee of the Central Association of Science and Mathematics Teachers on Content of High School Physics", Science and Mathematics. March 1921 p. p. 274-279
3. Hurd, A. W. North Central Association Quarterly, March '29 p. p. 589-614
   Hurd, A. W. North Central Association Quarterly, Sept. '29 p. p. 277-293

The objectives of a physics course as set forth by the North Central Association are summarized as follows: "Physics (a) reveals and interprets physical life, giving breadth, perspective, and balanced appreciations; (b) develops a rational individual able to use certain specific knowledge, skills, interests, abilities, or habits in better solving the everyday problems of life; (c) develops social and vocational efficiency; (d) prepares students for college entrance; and (e) teaches the laws and principles of physics."[1] Using these rather vague objectives Hurd formulated a unit plan which went from the specific every day life situations back to the generalizations that must accompany any physics course. He carried these units into high school and experimentally, with the aid of a battery of achievement tests, measured results. He found in comparing this new approach with the old method that there was appreciable gain by the new method. As a result of these investigations Hurd published a work test book in Physics which seemed to put into practice the plan by the Vestal committee that has just been stated.[2] What ultimate effect will be had by this work is rather difficult to forsee but up to the present writing (1933), it does not seem to have made any startling change in the texts nor the way physics is taught in the great majority of high schools. In nineteen thirty-two a committee for the National Society for the Study of Education published in their year book a program for Teaching Science. In this report a list of principles and generalizations were suggested for guidance in the selection of specific objectives of Science teaching throughout the elementary, junior high, and high schools.[3]

1. Hurd, A. W. North Central Association Quarterly, Sept. '29 p.p. 277-293 March '29 p.p. 589-614
2. Hurd, A. W. Work Test Book in Physics, McMillin, 1930
3. National Society for the Study of Education, 31st Year Book Part I, p. 53

They later say in regard to the physics course "It is the opinion of this committee that the underlying major generalization necessary for the understanding of phenomena and applications of the field of physics should be used as a criterion for the selection of the content of the course in high-school physics." "For the high-school course it is suggested that the concept, the indestructibility of matter and energy, and the concept, all physical phenomena are based upon energy transformations, be accepted as tentative organizing themes. The acceptance of such basic concepts as the central themes of organization for the high-school physics course could avoid the traditional compartmentalization of physics into short, separate, unrelated sections, almost short courses in themselves, without meaningful interrelations."[1] Their objectives are "to develop better understandings of, and abilities to use, those fundamental concepts and major generalizations of physics that will enable them better to interpret natural phenomena, common applications of physical principles, and industrial applications of the principles of physics."[1] It remains to be seen whether these vague generalizations will be welded into a course that will be satisfactory to all the interests involved. There is no question but that, if the course is to meet life situations, it will have to vary for different communities, which will in itself involve the outlining of a course by practically every teacher of the subject. This, at the outset, presents a difficulty that will be hard to overcome. Then, again, there is the question of preparing a number of pupils for college entrance. Great care will have to be taken that the fundamentals that are required by their entrance requirements are included in the course. It is true that the old major concepts that we have followed for years may be covered by such a course as suggested and, with this as a starting point, great things may be accomplished in the future.

1. National Society for the Study of Education, 31st Year Book, Part I, p.p. 255-250

If the above is true, the examinations that cover the field of physics need not differ for either method of approach. What has been said about tests previously may be regarded as applying to the traditional approach or to the approach by way of life situations. The high-school physics course is inherently a problem course and, as a result, our achievement tests should be mainly of the thought type. The test requiring fact answers has a use in the field in making sure that the memory material, or the tools of physics, has been acquired. But in the achievement tests we should judge the student not on how well he memorizes facts, but how well he applies those memorized facts. Therefore in judging an examination we must choose them from the point of view of what we wish to accomplish. Consequently when the writer takes up the evaluation of the test, he will state merely the number and percentage of fact and thought items.

These recent developments in physics have not progressed far enough so that we may judge our present examination in the light of these new curricula. Even when they are fully developed, there is no reason to believe that they will not include all the material that we have at present. The topics covered will probably be mechanics, heat, sound, light and electricity. In the amount of time given to each one we must take into consideration the requirements of the college entrance board and to the composition of the current text books. J. M. Hughes in 1926 made a study of the most frequently used text books. He found a striking similarity among the texts--70 of 73 topics being common to all three of the most frequently used texts. He also found that the selection of the material for text books is a decided factor in determining what is actually taught.[1] C. J. Peters in the same year found that of the teachers in Missouri,

1. Hughes, J. M. "A Study of the Content of the Course in High-School Physics." School Science and Mathematics, June 1926, p.p. 619-623

of the 50 percent using the most popular text almost 100 percent were following the organization of the larger divisions of the text. Ninety percent of all the teachers replying were using the organization of the adopted text.[1] L. A. Barrett in 1929 made a similar investigation in Colorado. He found seven text books in use. He analyzed these texts and found that the mean space devoted to each topic was as follows: Mechanics-33.79%, Heat-14.88%, Sound-7.98%, Electricity-30.39%, Light-12.96%. In the percentage compositions of each book devoted to each topic he found that they were very nearly alike.[2] The writer analyzed four other text books, two of which were published in 1932, in the same way as above. The mean percentage composition was as follows: Mechanics-33.39%, Heat-13.93%, Sound-5.64%, Electricity -32.35%, and Light-14.15%. It will be noticed how nearly the two sets of results coincide. A composite of these two investigations gives Mechanics 33.64%, Heat 14.53%, Sound 7.14%, Electricity 31.10%, Light 13.38%. It will be noticed that these correspond very closely to the College Board requirements which are as follows: Mechanics 30%, Heat 15%, Sound 10%, Electricity 30%, and Light 15%. The writer will, therefore, take this percentage composition as a basis for judging the percentage composition of the examinations that shall be evaluated in a later chapter.

1. Peters, C. J. "An Evaluation of a Reorganization of the Present Core of Subject Matter in High-school Physics." School Science and Mathematics, February 1927 p. 172.
2. Barrett, L. A. "A Comparative Study of Seven High-school Physics Text Books." Master's Thesis, University of Colorado, 1929.

CHAPTER III

THE NEW TYPE EXAMINATION IN STANDARDIZED TESTS

Although a greater number of the objective tests given by the teacher, and rightly so, are of the informal, teacher-made type, there are many of the so-called standardized tests published at the present time. The greater number of tests given should be these informal ones, but there are a number of advantages offered in the use of the standardized test.

The very name itself gives some information as to what they are, objective examinations with norms or standard achievements. As to whether these are the real value of an objective test there is some doubt. Symonds[1] seems to think that the standardized test has no value if it has no norms, while Ruch shows that the norms of a standardized test are of less importance than some other attributes.[2] There is no doubt, however, that the norms in a standard examination have some value in the interpretation of a test and of classfying the results of your own pupils with those that have taken it elsewhere. It also has a diagnostic value in that it shows that there is a weakness or a strength in the teaching as it is conducted by the teacher. Jones says of this that "the preparation of a test, or series of tests, in the modern sense means, not the setting or an examination but statement of a standard of attainment which all normal individuals should reach with variations in speed and excellence according to natural and cultivated ability."[3]

A standard test must, however, have more requirements than just norms. They are usually more scientifically and more carefully made than the ordinary type. Usually the authors are more familiar with the construction of these tests and are more acquainted with

1. Symonds, P. M. Measurement in Secondary Education; p.302
2. Ruch, G. M. The Objective or New Type Examination; p.139
3. Jones, "Practice Exercises in Physics," School Review;'26p.p.341

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the subject matter than ordinary teachers. Even at that, as will be seen later in the evaluation of the tests published up to the present time, there are a great many tests that do not fulfill the simple elementary requirements of a standard test. We are apt, at the present time, to lose sight of the curriculum considerations and pay more attention to the factor of secondary importance, methods. Unless the test satisfies three primary or major criteria, the test is of no value except in extreme cases. Wilson and Hoke list three major factors that we should look for in any standard examination.

They are as follows: (1) "That the test should be in harmony with and reinforce the right curricular principles (2) A test should encourage, supplement, and reinforce proper methods of teaching, and (3) A test should serve the true purposes of an examination. A good examination is the best teaching that can be done at the time and provides for a new view, a reorganization, or a worth while application."

Validity, reliability, norms, etc. are classed as secondary criteria.[1] We are apt in considering these examination to lose sight of the points listed above and consequently every test should be considered from these three angles before we take up the question of validity, reliability, norms, etc.

After the above conditions are satisfied, we may then take into consideration the mechanical factors of the examination. In addition to norms, the reliability and validity of the test tends to be higher than those made by the ordinary class room teacher. This does not infer, however, that all published tests have necessarily a high validity and reliability. Indeed, some of the tests that are in common use and are held in high repute have a lower reliability and validity than the many of the ordinary teacher-made examination.[1a]

1. Wilson, G. M. & Hoke, K. J. How to Measure revised edition p.p. 515-521

1a. Ruch, G. M. The Objective or New Type Examination p.23

Care must be taken in the selection of an examination that it has a relatively high validity and reliability.

Another advantage of the standard examination is that it saves a great deal of time, both in scoring and preparation. Usually there is a key that accompanies the test that may be placed over the paper to be corrected, and thus a great deal of time is saved. It may even be put in the hands of a good clerk who has no knowledge of physics whatever with the same results as if it were corrected by some one who is well versed in the subject. To any one that has made out a new type examination the advantage of time saving in preparation may be realized. It is a well known fact that by far the greater amount of time spent with a new type examination is used in its preparation and even after the items are prepared there may be some doubt in the mind of the maker as to whether the question was as good as one which would be presented in a standard examination.

Another point in its favor is that there will be relatively high objectivity in a well made examination. The questions have been so gone over and corrected and those showing any subjectivity been thrown out that the remainder could only be answered in one way.

Finally, the standard examination generally has two or more equivalent forms. Thus, if we should want to test a group with tests of about the same difficulty, we could do it, and so measure the achievement of the group. It would also be possible to test those who were absent from an examination with a test of the same difficulty as given the others. It is very difficult for a teacher to prepare another form of a test that will have the same difficulty as one previously given.

If, then, we are to use those standard tests, it would be well for us to consider just what we should look for in a test of this kind. Wilson and Hoke have given a very adequate list of what to

look for in a standardized test. Attention is called to this because it includes three important factors that are neglected by other books on tests and measurements. These three factors have to do with curriculum, rather than the mechanics of the test. We are apt to lose sight of the fact that the test is essentially a test in physics and that it is merely a means to an end and not the ultimate end toward which we are working. The points brought out by Wilson and Hoke are mentioned above. This, of course, does not belittle the use of new type tests in any way. It simply means that these criteria must be met before a test should even be considered. If these conditions are not met the test should be looked upon with grave doubt and except in very rare cases should be eliminated.

After these curriculum considerations have been taken into account, we can come to the methods of the tests. Even if the above criteria are satisfied, the test may not be so good as it might be. There is a great deal said about the mechanics of standard tests in all books on testing. The writer will quote a few of these. Wilson & Hoke after they have called attention to the major criteria go on to give a valuable list of minor criteria. They are as follows: 1. The following are some of the ways in which a test may be made more valid--(a) it may be modified so as to correlate more highly with a valid criteria, (b) it may be modified so as to be more nearly non-coachable, (c) it may be extended so as to measure more comprehensively the trait or ability in question, (d) ambiguities may be eliminated, and (e) the elements for the test may be more correctly weighted. 2. A test may be made more accurate--(a) by placing in it elements so easy that no pupil will make a zero score, (b) by placing in it elements so difficult that no pupil will make perfect score, (c) by having the differences among elements or steps small enough that there will be no undistributed scores, and (d) by requiring the score in a statistical form instead of in the form of a letter, work, or general phrase. 3. The following are some of the ways in which reliability and objectivity may be increased--(a) Arrange that pupil responses shall be controlled and as brief as possible, (b) Make the instructions for administering the test so definite that uniformity will be secured, (c) Give instructions so that the test will be easily and uniformly scored. The aim is frequently best accomplished by the preparation of a key which covers every possible response for which credit should be given. (d) The reliability of the test is increased by its being long enough to yield reliable scores and being comprehensive enough to yield reliable scores. (e) The test should be properly and adequately scaled, the units should be of equal or of

known value. In a speed test the units are usually equal; in a power test they increase uniformly in difficulty. The latter correlates more highly with intelligence. (f) Norms or standards must be available in terms of age and grade and other factors of individual variability. 4. A test should be economical and convenient, and, therefore, as useful as possible, (a) For general school use a test should be applicable to school-sized groups at one time. (b) The test should be simple and brief, instructions should be brief and definite, the time taken for scoring should be short. (c) Economy in interpretation is facilitated by proper norms and standards as indicated under 2 above. (d) The test should have several forms, at least three, preferably more, so as to facilitate retesting. (e) It should point the way to remedial instruction.[1]

Rich has given the following things to keep in mind when selecting a test. "1. Relevance or validity significance. No matter how good a test may be, as a measuring instrument, if it does not give the particular information which is in point, its indications are either valueless or misleading. 2. Reliability. A test is reliable when it is known to measure consistently the same results or combination of results on repeated use with the same pupils. Reliability is expressed by a coefficient. A general practice among educational measurers considers that reliability coefficients of less than .50 indicates tests of little value. The highest reported coefficients in any few are about .90. In sciences they seldom run above .70. 3. Availability. It is not enough that a test or set of tests be published and may be bought by packages or hundreds, unless the equipment for using the test is convenient and adequate, little satisfactory use of it can be made. The necessary equipment for successful use of a test includes usually (a) Definite and full directions for giving the test, so that its procedure is kept constant, (b) scoring keys, so that individual opinions in making results is eliminated, time saved, and accuracy secured, (c) Norms, that is recorded known attainments against which to measure results with the test. A fully adequate set of norms is perhaps the most difficult item of equipment to find, for it should include not only average scores (means and medians) but some indication of range of scores formed and should include these for as many stages in pupil's progress as possible within the time of applicability of the test."[2]

2. Rich, S. G. "The Available Tests for Results of Teaching Science" School Science and Mathematics 26; p.p. 845-852

1. Wilson, G. M. and Hoke, K. J. How to Measure in Education, revised edition; p.p.515-521

These form an essential outline of what to look for in regard to minor criteria in a standard examination. There are some points which might be added which are essential in searching for the right examination to use. Dr. S. A. Otis has drawn up a rating scale to be used in choosing examinations. It is as follows, Manual, 5 points; validity, 15; reliability, 10; reputation, 5; ease of administration which includes the following, (a) preparation, (4) time limits (4) (c) explanation needed (3) (d) alternative forms (4); ease of scoring which includes the following, (a) objectivity (10); (b) time required (3) (c) simplicity (2); ease of interpretation which includes (a) Norms (5) (b) direction for interpreting (4) (c) class record (1); (d) application of results (5); convenient packages, 5; typography and makeup, 5; test service, 10. The total is 100 points.[1] Ruch seems to think that Otis' scale places too little weight upon validity and reliability in comparison with administrative convenience. However, if the correct weighting were given to the reliability and validity this would probably make an ideal scale for secondary criteria. He has included many if not all of the points made by Ruch & Stoddard in their presentation of a criteria for selection of standard examinations. They have gone more into detail, however, and have asked a number of questions under each heading. There are, however, no ratings given each section.

In stating some of the things that, in the opinion of the writer, we must look for in an examination, no weighting will be given because the requirements of the examination may vary with different communities. He will also try to state the requirements in such a way that even the most uninitiated will understand for what to look and will not be bothered with a lot of statistical terms.

1. Ruch, G. M. The Objective or New Type Examination: p.p. 140-141

There is no way in which one person can decide for another whether a test is reenforcing the right curricula principles for his particular school. It may vary in different localities. The writer has attempted, however, in an earlier chapter to arrive at some outline upon which to base our evaluation of a test as to, (1) whether it is following the general curriculum that is accepted by the country at large as indicated by the uses which are made of the subject in after life, (2) the usual material encompassed by the leading text books, and (3) recent articles on the organization of a physics curriculum.

The individual teacher will have to decide for himself whether the particular test reinforces the proper method of teaching and whether it is the best teaching that can be done at the time. However, in order to aid the teacher in making a selection, the writer has listed the various types of questions in each examination and the number of thought and fact items in each test with the percentage of each. A table at the end of the discussion of each test will give these facts in brief while a comparative table at the end of the section will give at a glance the comparison of the various tests. No attempt has been made to classify the work books and the instructional tests.

After considering the major criteria we may turn to minor criteria. One of the most important things to look for is validity. Does it measure what it claims to measure, and how does the author prove that it does? This may be accomplished in a number of ways. One or two will be mentioned. Starch, in making out his examination, made a study of five widely used text books to determine the material which he was to use. Validity may also be ascertained by obtaining the judgment of competent persons, or by correlation with some outside critera.

Another point of importance is the reliability of a test. Does

it measure accurately that which it does measure? There are three points that favor a high reliability--1. objectivity of scoring, 2. extensive sampling, and 3. the length of the test.

The first point need not be especially bothersome, because if the test is of the new type, it will, by its very nature, be objective. The only possibility of subjectivity would be in the completion and the simple recall.

We can never get a complete sampling of any test, but we may approach nearer and nearer to it as the number of difficult questions are increased, but the knowledge of one or two questions in one unit is not a guarantee that the pupil will have knowledge of another unit, while knowledge of one question in a unit is a better guarantee of knowledge of other parts of that unit. Consequently, if we have a number of different questions from separate units we will get a better sampling and consequently a better reliability.[1]

A longer test is a better proof of reliability than a short one. There is, in existence, a formula by which we can predict the reliability of a test by increasing the number of questions.

Ruch points out thatagreat many standard tests by their shortness defeat their very purpose.[2]

The reliability of a test is measured as a coefficient of correlation usually expressed as a reliability coefficient. This may be done in one of three ways. It may be obtained, and this is usually the best, by correlating the scores of two duplicate forms. It may also be found by correlating the results of the same pupils given after a period of time or it may be obtained by breaking one form of an examination into chance halves. This latter process of course is not used very much in standardized tests, because there

1. Starch, D. Educational Measurements: p.88

2. Ruch, G. M. The Objective or New Type Examination

are usually two forms. The probability that the correlation will run higher than .70 in science tests is not very good.[1] Ruch gives his opinion in the following table.

Correlations of 0.00-0.25 are unsignificant.

Correlations of 0.25-0.50 are low.

Correlations of 0.50-0.80 are fairly significant.

Correlations of 0.80-0.95 are fairly high.

Correlations of 0.95-1.-- are high.

As time goes on, we are getting better and better tests in physics with resulting higher correlations.

Another important consideration is the ease of administration and scoring. The test must have complete and simple directions so that even the slowest pupils in the class may understand them. The test conditions should be well controlled by the directions given in the manual and a number of clear simple exercises given. There should be convenient scoring keys and stencils provided with the test and adequate directions for scoring and compiling the scores given. Some types are easier to score than others and it might be well to take this into consideration.

There should be an adequate set of norms provided together with the mean and median. Some idea of the range of the scores should be given. They are usually given so that they read in percentage of those below the score in question or in other words they are given in percentile ranks.

The test should also have two or more duplicate forms. It is important that these forms be equivalent. They can be used in a

1. Rich, S. G. "The Available Tests for Results in Teaching Science" School Science & Mathematics; p.p. 845-852

number of ways.[1]

There are a few mechanical advantages that should be taken into consideration. They should come in convenient packages, properly printed, and on good paper. The cost of the examinations should be within reason. If the price is high, it does not signify that the test is any better than one that is of a lower price. The cost of the test comes in its preparation. Some may have cost a great deal to prepare and some very little. The more costly test, however, may not be so good as the one that is less expensive.

The final consideration is the time required to give it. It should be long enough so that it will be consistent with reliability, and it should be short enough so that it does not cause the pupil to endure undue hardship. If the pupil is kept at it too long, it will mean that the reliability will suffer due to the pupil's fatigue and loss of interest.

1. Ruch, G. M. The Objective or New Type Examination; p. 90

CHAPTER IV

THE NEW TYPE TEACHER MADE EXAMINATION

The teacher who is going to choose a test for his own use must have in mind certain facts as to the make-up of an examination if he is to choose wisely. On account of the cost, non-adaptability, and lengths of time in periods of instruction, we cannot use standardized tests entirely, but must supplement them with informal teacher-made tests. "Perhaps at present there is too much attention being given to the new type examinations; this is certainly true if one allows the ill advised and lazy methods to masquerade as new type."[1] It is a deplorable fact that many of our teachers plunge right into the making and choosing of new type tests with absolutely no knowledge of how to go about it. The result is that the critics of the new type examinations have abundant material with which to heckle the proponents of this type examination. The writer will attempt to present a few salient facts in regard to the construction of an informal examination. In the first place there are certain facts that must be kept in mind when the test is being constructed. The teacher must decide just what he intends to accomplish by the use of the test. If the object of the test is to learn whether the pupil has thoroughly mastered fundamental laws, formulas or facts, the test should be made out with this thought in view and the questions should be mainly of the type classified as fact items. If, however, the purpose of the test is to discover whether the pupil has the ability to use these mastered facts in every day life situations, the questions should be of the type requiring a response that must be thought out with these mastered facts as a basis. If the object of the examination is to measure achievement, the questions might be a judicious sampling of both fact and thought items with a preponderance of

1. Farwell, H. W. "The New Type Examination in Physics," School and Society 19; p.p.315-322

CHAPTER IV

thought questions. Then again, the object may be mainly diagnostic. The questions may then be arranged so that the answers will point out where the pupil is weak or where the class as a whole is weak and indicate where remedial teaching may be of value.

In the second place, we must remember when we are making out an examination, especially one that covers the work of an entire semester, that it must be kept within the curriculum that is accepted as the requirements for the particular subject which, in this case, happens to be physics. The objectives which are being worked for must be kept in mind. In a subject like physics the test should not be made out to cover a great many scattered, unrelated, and unessential facts which obscure the greater objectives toward which we are working.

Another item which must be given consideration is the recurrence of old questions that have been taken up in class. This should not be permitted with the exception of fact items. New thought situations should be encountered so that the test may not be mere drudgery, but will give a new outlook on the topic.

After these factors have been taken into account we must take into consideration the mechanical features of the test. In the first place the examination should be highly objective. This caution is not necessary except in the case of completion and simple recall.

Another prime requisite is that the test should be reliable. Reliability refers to the degree to which a test measures whatever it does measure. The teacher ordinarily cannot try out two forms of a test, before using either, but should endeavor to secure enough reliability by length, and selection of items.[1] All other things being equal, the longer a test is the more reliable it is. If the form of the examination is such that similiar results are obtained each time

1. Ruch, G. H. The Objective or New Type Examination ; p.p. 40-63

the test is given, we know the reliability is higher than if entirely dissimiliar results are secured at each giving. Care should be taken in the selection of items so that they are worded to be not ambiguous, not subjective, and not capable of being interpreted in a different way than was intended by the instructor. The test should be so made that the directions are clearly given and that the illustrations showing the way in which the questions are to be answered are numerous.

Another qualification of importance is that the test shall be valid, that is, measure what it is supposed to measure. To say that a test is valid also infers that it is reliable. Validity may be obtained in a safe way by the following procedure. If, during the course of instruction, a good question is thought of it should be jotted down on card or in a note book. If they are gone over at some later date, a great many will be eliminated due to faulty wording, ambiguity, lack of application to the subject, and the like. When the test is made out, questions that do not fall within the instruction given, as determined by the course of study or competent text books, should be excluded. If there is more than one member of the department, the questions could be subjected to the scrutiny of all, and a number of invalid questions would thus be eliminated. As the tests are used from semester to semester, or year to year, the questions could be validated even more by studying the constantly recurring errors, or by asking the pupils why they gave the answer they did to a question that was given on the examination. We can also increase the validity by increasing the length. There is a limit to this, however, in the time limit set for the examination. "Few test workers know of the existance of a formula which enables one to predict the validity of a test when increased in length. Doubling a test in time limit and among of content not only in-

creases its reliability but normally increases its validity as well."1

The examination should be easy to give, easy for the pupils to take, and easy for the teacher to score. Neither the teacher not the pupil should be unduly burdened by the examination. The teacher should have time for other things besides the mere giving and correcting of examinations while the pupil should not be prejudiced against them by making them unduly hard.

The questions should be so constructed that they cannot be answered from general knowledge, thus obviating any possibility of guessing. They should, likewise, be so constructed that cheating is discouraged.

There should be an extensive sampling. The attempt should be made to measure as many phases of the individuals knowledge as possible.

It is best that a copy of the examination should be placed in the hands of each individual pupil. This does away with a great many errors in interpretation, and allows time for thought and interpretation of the question. The questions should be so arranged that there are some questions that are merely recall of facts, while others are of the thought provoking type. The questions should be of a type that will involve the interest of the student.

In making up an examination it is well to have some sort of guide as to how many questions can be answered in a minute. Of course no set time can be given because it will vary with different pupils and different examinations under different conditions. Ruch & Stoddard, however, give a table of rates at which the average high school pupils works.

1. Toops, Herbert A. "What Are We Failing to Measure in Education" Journal of Educational Research 13; 118-128p.p.

A few of these follow:

"Recall or completion, about four items per minute; 5 response and 3 response, about five items per minute; true-false about six items per minute."[1] Although four responses are not mentioned both three and five responses are given as about six items per minute so we can conclude that it would take about the same amount of time for the four response.

Chapman, in an early work on the new type test, stated what requirements should be fulfilled in making out a physics test. "It must apply specifically to the field of knowledge for which the test is constructed. 2. It must be taken from an essential part of the subject which is contributory to understanding or summarizing a general theory, or principle. The question in other words, should be such that a correct answer would indicate that a distinct meaning had been grasped. 3. It must be so worded as not be ambiguous. 4. It must, also, be so framed that it can be answered very concisely usually in a single word, or at most in a short phrase. 5. It must be such that the short answer given in the test includes all possible correct answers.[2]

Illustrations of Types of Questions

There are about seventeen different types of objective tests in use. Some apply to any subject; some to special subjects. It is the intention of the writer to discuss those that seem most suitable for use in physics.

The true-false test is a series of statements, or questions, if the instructor prefers, some of which are true and some false.

1. Ruch & Stoddard, Tests and Measurement in High School Instruction p. 293

2. Chapman, J. Crosby, "Measurement of Physics Information" School Review 27; p.p.748-756

These are marked, in the margin, generally the lefthand one, with a T or F, + or −, with the words true or false, or, as is now often used, the + or o, as the teacher dictates.

There is some evidence that this type possesses psychological and educational characteristics which are different from those of other types.[1]

William Asher carried out an experiment to examine the chances a person had, knowing nothing of the subject to be tested, and therefore having to guess, of obtaining a passing mark. A fictitious true-false test was made by shuffling 10 hearts and 10 spades and then drawing these, one by one, to determine the order of the true and false statements. The answers were guessed by an individual flipping coins, heads meaning he guessed the answer to be true; tails false.

This procedure was repeated for 20 imaginary individuals with the following results: -10, 0, 40, 10, 30, 10, 0, -30, 50, -40, 20, 20, 10, -30, -10, -10, -10, -30. If 70 or 75% is used as a passing grade, not one was able to pass through guessing.[2]

"Subjects appear to "guess" right oftener than chance will account for in response tests but to "guess" wrong oftener than right in the true-false type."[3]

"Some people are suspicious of chance so do not believe in such a test. The treasurer of a Sunday School once tossed pennies 50,000 times obtaining, as a result, 25,001 heads, and 24,999 tails. Two summer school teachers matched pennies several minutes daily all summer. At the start each had a bag of 100 pennies. Neither ever succeeded in entirely depleting the stock of the other. Chance is fatally exact when pennies, or statements in a test are numerous. Hence, there should be as many statements in a test as is practicable.

There are a few suggestions which will help teachers who may

1. Ruch and Stoddard, "Comparative Reliability of Five Types of Objective Examination." Journal of Ed. Psychology 16; p.p.89-103
2. Asher, William, "The Reliability of Test Requiring Alternative Responses" Journal of Ed. Research 9; p.p. 234-240
3. Ruch and Stoddard, "Comparative Reliability of Five Types of Objective Examinations" Journal of Educational Psychology 16; p.p. 89-103

wish to use the True-False test. First the teacher should so construct the test that it will contain approximately the same number of true and false statements. Second, the teacher should be careful to keep out of the tests all ambiguous statements. Third, the teacher should inspect not only this but any sort of test from the point of view of just what the test measures. Fourth, the teacher may so construct the examination as to force pupils to guess wrong, due to power of suggestion."[1]

The true questions should not be all together; neither should they be alternated in an exact pattern with the false questions. This leads to too much guessing. The two forms should be mixed in a rather hit-or-miss arrangement.

Examples

o 1. Like magnetic poles attract each other; unlike poles repel.

\+ 2. The human eye can be focused to see clearly objects at different distances by changing the curvature of the lens.

Matching tests, where usable, form an excellent type to employ. A matching test consists of two columns of items to be matched, one with the other. One may be a list of dates; the other, important events which took place on those dates. One may be a list of inventors; the other, those inventions perfected by them. It is well to have the first list in some sort of regular order--alphabetically or chronologically--as it enables the pupil to match them with the opposite, more-at-random list without loss of time.

The lists may be equal in length. The one objection to this is that the pupil, knowing the majority, may, by the process of elimination, guess the remainder. The second list may be shorter than the first, in which case the expressions in the shorter list are to be used more than once. The second list may be longer and some of the items are not to be used.

1. McCall, William W. "A New Kind of School Examination," Journal Of Educational Research I; p.p.34-36 Jan. 1920

The best number of pairs to be matched is about 10-12. Fewer than 10 allows for too much opportunity for guessing while more than 12 is wasteful of the student's time. In preparing a test of this sort, it is necessary to avoid the use of one or two plurals in an otherwise singular list, or of one or two dates only. This reduces the number from which to select to a very few alternatives.

Occasionally three columns are used. In one might be a man's name; in the second, a date or country; in the third, a scientific law or discovery.

Examples

3	1. Which is usually caused by poor insulation?	1. Condenser
1	2. Which involves the same principle as the Leyden Jar?	2. Coil 3. Short Circuit
4	3. In which one is the permanent magnet an essential part?	4. Telephone Receiver 5. Brushes
6	4. Which serves the same purpose in an electric circuit as the valve serves in a water circuit?	6. Rheostat

The multiple response, or as it is often times called, the multiple-choice, the multiple-answer, or the best answer type of test is, in the opinion of the writer, one of the best. This is, together with the true-false and matching tests, a recognition type.

In this test, the pupil is given a statement with several possible answers, or responses, from which he is to select the correct one. The number of responses varies, but, in the judgment of the writer, four is best. Too few leads to guessing, too many are awkward. It is often difficult to have all the responses reasonable. However, if the test is to be successful, they must be plausible to some degree.

Do not use any word or words, mixed parts of speech, or plurals and singulars which might serve to identify the correct answer. Do not use the first, second, third or fourth responses as the correct answer in each instance. Use the same number of responses through-

out the test.

To aid in correcting these questions, the writer suggests that blanks be left in the right-hand margin and that each response be lettered or numbered. The correct number or letter, in the estimation of the pupil, is then entered on the blank by him.

There are many variations of the multiple-response type. There is the one just discussed and its direct opposite. In this case the majority of responses are correct--the incorrect one is to be struck out. Sometimes more than one is correct---or incorrect. The responses may be definitions or reasons. Unpreceded by any question or statement may be a list, let us say, of scientific terms. In this list, one does not belong because it is not a scientific expression. The directions are to cross off the one not associated with the remainder. Another type calls for two or more answers to each statement, but of a different character. Hence, a law might be given by its scientific name. The two responses sought would be the author or discoverer of the law and, perhaps, a brief explanation of it.

Examples

1. The leyden jar is a type of (1) electrical battery, (2) cell, (3) condensor, (4) transformer. 1. 3

2. A magnet will attract pieces of (1) iron, (2) copper, (3) silver, (4) paper. 2. 1

The rearrangement type of test consists of a list of items, dates, names, happenings, substances, or other series in a confused order. The pupil is to arrange them in some set order--Chronologically, alphabetically, or in the order of operations, perhaps. We might enumerate a list of substances to be arranged in the order of specific gravity; we might list the steps used to find the coefficient of linear expansion, or the operations used to discover the speed of light or sound.

To the physics teacher the use of this type as a means of locating various steps in an operation is particularly valuable in testing the results of laboratory work, as it enables him to test the reasoning power of the pupil as well as the subject matter gained in the course.

Perhaps the best number in a list for rearrangement should be not over ten, or less than that is preferable, if possible to so compose the items.

The question of scoring enters into this kind of test, unfortunately. To the student who rearranges his answers in the correct form must, of course, go the highest score. But should the pupil who succeeds in rearranging his responses in a nearly correct fashion suffer the same plight as the boy or girl who, knowing little of the operation, answers not at all, or very poorly?

Odell offers one possible solution which has, he admits, its drawbacks. He writes, "Let the total number of possible points, that is, the number given for an entirely correct answer on any particular exercise, be equal to the greatest possible sum of differences, that is the sum of the differences between the correct order and the most incorrect order possible."[1] These sums for numbers of items from four to ten are shown below.

No. of items	Sum of differences
4	8
5	12
6	18
7	24
8	32
9	40
10	50

If the number of items is even, the sum of the differences is equal to one half the square of the number; if it is odd, the sum equals one half of one less than the square.

"The sum of the differences between the order actually given by a pupil and the correct order should be found and subtracted from the greatest possible sum of the differences, and the remainder taken as his score."[2]

1 and 2. Odell, C. W. Educational Measurement in High School; p.p. 495-496

For example--

Score Total possible Differences-Sum of actual differences.
8 item test

Correct order	Pupils order	Difference	
4	1	3	
6	6	0	
8	3	5	
1	4	3	
5	8	3	
2	2	0	
7	7	0	Score--32—16=16
3	5	2	
		16	

Another suggested type is the Curetan-Dunlap method of scoring

Correct Order	Pupils Order	Difference	Difference Squared	
4	1	3	9	
6	6	0	0	
8	3	5	25	$\%\text{Score}--100-\frac{300sd^2}{N(N^2-1}$
1	4	3	9	
5	8	3	9	
2	2	0	0	$\%\text{Score}--100-\frac{300(56)}{8(63)}=69\%$
7	7	0	0	
3	5	2	4	
			56	

In using the Odell method it is possible to score 22 per minute while the Curetan-Dunlap method is much slower, it being possible to score only 10 in one minute.

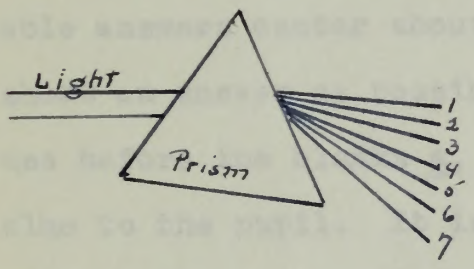
There is, too, the identification type of question used preferably, in physics, with a diagram. The diagram may be of a machine or a piece of laboratory apparatus. Certain parts of this drawing are numbered or lettered. Below the picture are a number of items or expressions equal to or exceeding the number of lettered parts on the diagram. Beside each name is a blank. In each, the pupil is to write the letter which he thinks points out on the diagram the part corresponding to the word opposite the blank.

The scoring of these is the number correct subtracted from the total number given. It is an excellent method to use when time is

short as almost no writing is required from the pupil.

Sometimes the pupil is asked to number the parts given. This is often unsatisfactory though, as he is inclined to be careless in the exact placing of his numerals or letters and, while his knowledge is correct, his inability to be precise leads to a lower score than he should have.

Examples

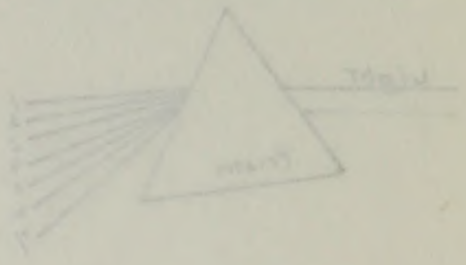


1. Put the color corresponding to the number on the diagram in the space provided at the right.

1. Red
2. Orange
3. Yellow
4. Green
5. Blue
6. Indigo
7. Violet

One of the most widely used, and perhaps one of the most ideal forms is called the simple-recall. It combines the rapidity of correction of the true-false with the comparative impossibility of guessing of the completion type. The drawback is, however, that this type is not as objective as some of the others. Often-times the word filled in is not the one desired by the teacher, but may be along the same line of reasoning.[1] The teacher must use judgment in scoring in this case.

1. Symonds, P. M. Measurements in Secondary Education; p.37



The recall form is more reliable than the recognition types (multiple-response and true-false) are for a constant number of items.

A pupil should be able to do 100 of these in approximately 25.7 minutes--or about 4 each minute.[1]

In preparing a test of this type the teacher should avoid questions which could be answered by the use of general intelligence without the knowledge of the particular study. Since it is unavoidable that several answers may be given for one blank, make all acceptable answers center about one thought. Make the question call for as short an answer as possible--a single word or date is best. Do not use before the blanks a, an, or any other word which might give a clue to the pupil. It is easier to score if all blanks are at the right hand margin.

Examples

1. The number of inches in a meter is approximately 39.37
2. The phenomena caused by the interference between two sound waves of nearly the same frequency are called beats

The completion test is similar to the simple-recall type, although it allows more freedom of expression in the answers. It may be used in almost any school subject.

Care should be used in constructing this form that it may be objective. Do not have a number of blanks in one sentence. This is confusing to the pupil and the results are often, while true, not those sought.

In a study made by Garnette Earl Greene, "The problem involved in this discussion is a study of the reliability of the forms of blanks used in completion tests. The forms used are equal length blanks, which in no way indicate the kind of work which should be placed in them,

1. Ruch & Stoddard, "Comparative Reliability of Five Types of Objective Examinations" Journal of Educational Psychology 16: p.p. 89-103

varying length blanks, which vary in length with the size of the word which should be placed in them; and dotted blanks when dots represent the number of letters which should be placed in the blanks.

"No one of the three blank forms shows an outstanding higher reliability than either of the other two forms."[1]

"The reliability of the Completion Type Test is higher than is that of either the True-False or Multiple-Choice type."[2] In a study undertaken to determine the relative validity of the three types of questions, multiple choice, completion, true-false, the following results were determined. There is a slight, but real, advantage in the validity of the completion test over the other two.[1a]

Sometimes in a completion-test, no help is given. Sometimes a list of words to be used to fill the blanks follows the to-be-completed statements. These may equal in number the blanks to be filled, may exceed the blanks and thus contain some which are not usuable, or may be less than the number of blanks and to be used more than once.

Examples

1. The mechanical advantage of any lever is the ratio of (1)_____ to (2)_____
2. The ratio of the speed of light in (3)____ to its speed in any medium is called the index of refraction.

1. Load
2. Effort
3. Air

Some Uses of New Type Tests

There are various reasons presented as to why examinations are given. The main purpose in the past seems to have been to furnish a grade that could be assigned to a pupil so that he could be classified

1. Greene, Garnette Earl, "Comparative Reliability of Blank forms Used in Completion Test in H. S. Physics" Master's Degree Thesis U. of Colorado, 1927
2. Lohr, Vergil C. "A Comparison of Some Tests Given in H. S. Physics" "School Science & Mathematics 27; p.p.74-85

la. Brinkley, Sterling C., "Relative Value of Different Types of Questions in Reading Tests" School Science & Math.25; p.p. 703-707

and promoted or not promoted. Although this may still be one of the fundamental uses of tests there are others which are as, if not more, important than the one given. Wilson and Hoke give a list of the uses of standardized tests. While some of these are for the standardized test alone, a great many of them also apply to the informal teacher-made type. These uses are as follows:

1. To determine conclusively whether or not a pupil is making progress. A pupil is entitled to just treatment. 2. To determine how much progress a pupil has made in a given time. 3. To diagnose pupils abilities and weaknesses, so that the work of the teacher may be specific. This is one of the most valuable uses of standardized tests. 4. To determine whether a pupil should be promoted, retained or reclassified, in so far as mastery of subject matter is made a condition of progress. Dr. Starch states that promotion on the basis of measured ability would save one year for one-third of the pupils of public schools. 5. To determine even more accurately whether or not the class is making progress and the amount of such progress. 6. To determine whether or not a class is up to standard when received from another teacher. This use of the standard test would remove the constant complaint of teachers that the work has not been covered in the preceding grades. 7. To justify a years work with a class on the basis of actually measured progress. This will make it possible to show to a prejudiced principal or superintendant that reasonable progress has been made by a class. 8. To show results in a manner that completely discredits the advantages of another teacher more attractive and popular, in case such depends upon coming promotion by methods not contributing to pupil progress. 9. To detect the fact in case more time cannot profitably be spent with retarded pupils. 10. To release bright pupils from further work after determined standards have been reached, as long as said standards are maintained. The teacher would thus limit the work required along mechanical and routine lines. 11. To test one method against another by the amount of measured progress made by the pupils. It is apparent that such use of standardized tests would replace the trial and error method as a means of determining correct procedure and would replace it by a method much more scientific. 12. To test one class plan, study plan or administrative devise against another by measured results with the pupils. 13. To determine the proper apportionment of school time to various subjects of study and other school activities.[1]

The above list is very complete and includes about every possible use we could have for a test.

The purposes of a test are given by Symonds as follows:

1. To inform pupils of their achievement, 2. As incentive to study, 3. To promote competition, 4. To determine promotion, 5. To

1. Wilson, G. M. & Hoke, K. J. How to Measure Revised Edition p.559

diagnose weak spots in the pupils achievements, 6. To determine the quality of instructions, 7. To determine admission to high school, 8. To place a pupil in school,9. To determine admission to college, 10. To provide reports to parents, 11. To determine credits, honors, etc., 12. Educational and vocational guidance, 13. To rate teachers, 14. To predict a pupil's success, 15. To study the efficiency of the school."[1]

Odell sums it up under fewer heads. The examination may be used for"1. The measurement of pupils ability and accomplishment, 2. The diagnosis of pupils, especially of those doing unsatisfactory work, 3. Measurement and improvement of teaching efficiency,4. The provision of opportunities for learning, 5. The motivation of pupil study and other mental activity,6. The determination of standard goals of attainment."[1a] Some of you might argue that part of these could be measured just as well with the old type examination and this might be true, but unless we get a more objective method of marking, the rating with the old type of examination is worse than nothing.

The lists of uses of the new type tests given above might be condensed to the following list. The new type examination may be used, 1. As a means of grading, 2. As a means of motivation, 3. As a means of prognosis, 4. As a means of diagnosis and remedial work and 5. As a measure of achievement.

It is a well known fact that different pupils have different abilities for learning. During the past, little consideration has been taken of this fact and, as a result, we have the fast and the slow going along together in the same class. Recognition must be taken of their different abilities and it is by means of these new type tests that this is possible. As a usual thing the teachers aim at the middle group. The work presented is too easy for the quick child and too fast for the slow child. By means of these new type tests we are able to segregate them and provide more drill for the slow and more work for the quick. We have not done so much in this

1. Symonds-Measurement in Secondary Education

1a. Odell, C. W. Traditional Examinations and New Type Tests

field as we might, in connection with physics.

The other reason for grading, of course, is the one that we are most accustomed to. Ruch & Stoddard say, "The primary aim of all examinations, tests, or school marks is that of ranking the pupils in approximately true order of merit upon a scale of ability."[1]

The original aim of the examination was to provide a rating that could be sent home for the parents' inspection and provide a means of determination of promotion or retardation. The new tests give a more accurate record of ranking because it is objective and consequently is a better means than the old type test for this sort of work.

That any type examination is a means of motivation has long been a disputed question. Unfortunately we haven't much proof that the examination is a form of motivation. T. H. Schutter of the Oregon Normal School has conducted such an experiment, however, along this line. Four classes were utilized, two each term. One of the classes each term expected an examination, the other did not. The groups were tested and showed about equal mental ability. When examinations were given, the results of those who did not expect the examination correlated very unsignificantly with the "intelligence" scores, while the results of those expecting the test, correlated very highly. It appears that better use was made of existing mental ability in the second group. Doubtless the examination group learned with a more definite idea of retaining the material of the course, than did the other group. The effect was a clearer and more lasting impression which produced better daily work and which was conspicuous also in the final examination results.[1a]

1. Ruch & Stoddard, Tests and Measurement in High School Instruction; p.29

1a. Schutter, T. H. "Is There Any Value in the Final Examination?" Journal of Educational Research 12; p.p.204-213

The above would tend to show that the examination provided a means of motivation. The writer has used the short test as a means of motivation for some time. A few years ago, he carried out the following experiment. Two sections in physics were given no daily quiz, while two sections were given a five minute quiz each morning. The average intelligence ranking of the two groups varied by a very small margin. The scores obtained from a new type test were higher in those that had had the five minute test. The pupils who were taking the short tests studied from day to day with the intention of remembering, and this apparently carried over to the longer tests.

Whether this is a type of cramming or not depends upon the instructor, the course, and the pupil. If the studying is spread over a long period of time, it is, of course, a good means of motivation; and if the pupil feels sure that he is to get a just examination, he will have all the more incentive to study.

Although we have a great many so called prognostic tests on the market, we are really only in the experimental stage in regard to this type of work. There are only one or two published which are intended to apply in the field of physics.

The only ones with which the writer is familiar at the present time are "The Thurstone Vocational Guidance Test in Physics" and the "Iowa Placement Examinations (Physics Aptitude and Physics Training)". There is still some doubt as to whether these examinations predict success in physics. Guy W. Wagner made a study of the relative value of various tests as a prognosis of success in High School Physics.

He says, "Of the many phases involved in determining success in physics, five were used in order to weigh their respective value in predicting success. The five studied were, 1. Terman Mental Test, 2. Iowa High School Silent Reading Test,3. Iowa Placement Aptitude Physics Test,4. Iowa Placement Mathematic Aptitude Test, 5. Hotz Algebra Test on Equations and Formulas. The success of the 120 physics students studied were determined subjectively by teachers marks and objectively by the Columbia Research Bureau Physics Test

Form A. The use of any of the initial test scores individually or in combination, as a means of predicting success in physics were found to give predictions only slightly better than guessing. The Physics Aptitude Test offered the best method of predictions with a prophesy of 12% better than guessing. The chief criticism of the initial tests used is that they do not measure comprehensively enough all of the aspects involved in determining success in physics. The author concludes that success in physics probably can be predicted, but this will involve the determination and measurement of influencing factors not ascertained by the prognostic tests in this study."[1]

That the success can be predicted there is no doubt, and the best possible solution at the present seems to be in the general direction that the Physics Aptitude Test follows. However, this still presents a great field for investigation and research, and, before many years, we may be able to predict, with a great deal more certainty, success in physics as has been done in a number of other fields.

What is now considered by some as the most important use of the new type examination is as a means of diagnosis and remedial work. "The giving of the test in itself is of little value, but should be followed by diagnosis and remedial measures. Tests suitable for this purpose are not commercially available in sufficient quantities for all phases of all subjects, therefore the teacher should supplement those that can be purchased with many of her own."[2]

Until very recently there have been no tests put out especially for this use in physics, but, with the introduction of unit tests by Sangren & Marburger, and the set of tests by Glenn & Obourn, the field of physics is supplied with a competent set of tests upon which to base remedial work, which are discussed in Chapter V, and Appendix I.

1. Wagner, Guy W. "The Relative Value of Various Tests as a Prognosis of Success in High School Physics" Master's Thesis, State U. Iowa 1929

2. Odell, C. W. Educational Measurement in High School;p.549

"The typical school examination covers a variety of topics. Thus the "Grade" which a pupil receives is an average or general measure. It does not furnish an index of his particular weaknesses. It does not tell in what topics he is strong and in what topics he is weak. The ordinary examination is not diagnostic. For certain purposes, diagnostic measures are required. In such cases the general measures yielded by ordinary examinations have a limited usefulness."[1] As a result, we have devised tests of the new type which show up a pupils weaknesses, so that remedial work can be attempted.

That remedial instruction pays, there can be no doubt. A. W. Hurd conducted an experiment during 1930-1931 which seems to prove this point. His conclusions are as follows. "Remedial instruction does pay, then, in terms of measured achievement. This statement is premised by the supposition that instruction is directed toward the objectives which the tests are designed to measure."[2]

1. Monroe, W. S. The Theory of Educational Measurements

2. Hurd, A. W. "Does Remedial Instruction Pay?"34;p.3,1931 School and Society

The type of examination that can be made out by individual instructors is well illustrated by work done by Lynn Louis Ralya. He realized the need for this type of examination in his own work and consequently drew up a set of tests to cover the first semester of a physics course. In constructing these tests he kept the following principles in mind. "1. People think only when confronted by a problematical situation, 2. We have to have facts to think with, but they are not ends in themselves, 3. We have to have words or symbols to think with, but the mere ability to repeat them does not assure possession of the corresponding concepts, 4. Repeated thinking through of problems involving a principle, results in greater, real understanding of the principle than does a mere repetition of the principle of words, 5. A person becomes more aware of a principle when he makes the discovery himself (through guided assistances if need be, but with his taking the final step,) 6. That success conditions interest which in turn conditions effort, resulting in greater future achievement, 7. That intellectual success consists in seeing real reasons why, and in being able to generalize and to apply."[1] We might well keep these points in mind when constructing any test, as they might apply when the test is used as a teaching device as well as an instrument of measurement and diagnosis.

We could then build this type of test ourselves or use some published test to show up weaknesses in a group as a whole, or individual weaknesses.

The final use of the new type test is as a measure of achievement. Some phases of this purpose may have been brought out in connection with some of the other points that have been mentioned. The uses of measures of achievements might be summed up as follows. 1. To rank the school in regard to achievement of other schools, 2. To rank the pupils in relation to each other in the class, 3. To measure the efficiency of the instructor, 4. To provide ranks for promotion, 5. To provide grades for reports to parents, 6. To promote competition between various pupils, 7. To determine credits, honors, etc.

1. Ralya, Lynn Louis "Diagnostic Tests and Remedial Instruction in Physics", Master's Thesis, University of Wisconsin, 1930

It is to our great discredit that we do not take full advantage of all the possibilities presented by this type of examination.

Advantages and Limitations of New Type Examinations

Although it is true that the traditional examination has certain advantages that cannot be taken care of by the new type examination, nevertheless a great many teachers have felt that the old type has a great many failings that may be overcome by the new type test.[1] Among these failings are, the subjectivity of scoring lowers the reliability or accuracy of the mark, bluffing often times occurs and is some times encouraged, a pupil wastes a great deal of time writing lengthy answers, the sampling is limited to a small number of topics,[2] and too much time is taken up scoring the papers.

There are numerous investigations that prove beyond a doubt that the scoring of essay type questions is purely subjective. Starch & Elliott have shown the wide variation of teachers marks on one paper in their experiments conducted in English, History and Geometry. [3&4]

Probably the classic example is the one stated by Wood. "One of the five or six expert readers assigned to a certain group of history papers, after scoring a few, wrote out for his own convenience what he considered a model paper for the given set of ten questions. By some mischance this model fell into the hands of another reader who graded it in bona fide fashion. The mark he assigned to it was below passing, and, in accordance with the custom, this model was rated by a number of other expert readers in order to insure that it was properly marked. The marks assigned to it by these readers varied from 40 to 90.[5]" Other experiments have been carried on by Ruch & Wood which have tended to prove the conclusions first stated by Starch & Elliott.

Physics is said to be a subject in which the answer is either wrong or right and therefore it is more or less objective. This is

1. Wood, B. D. Measurement in Higher Education;p.p.191-198
2. Ruch, G. M. The Objective or New Type Examination; p.p.70-100
3-4. Starch and Elliott, School Review 20;p.p.442-457,21;p.p.254-259
21;p.p.676-687
5. Wood, B. D. Educational Administration & Supervision;8 1921
p.p.302-304

not true, however, because "although many consider physics a right or wrong subject, it is not unusual to find two men differing in the rating of an answer."[1]

There is no doubt that this subjectivity can be cut down by using a set of scoring rules, but even then it is never as objective as the new type examination. On the whole it seems better to change the type of examination rather than to try to improve the old type. The human element varies from day to day, or even from paper to paper.

There is no question that a pupil will bluff his way thru a question if given the opportunity. "Pupils know with a somewhat uncanny intuition that teachers are loth to mark any question zero unless the question is left absolutely blank. There is an ever-present, and perfectly human and philanthropic, tendency to reward effort no matter how misguided and futile."[2] And, too, if a pupil has written good answers to the other questions the teacher will be charitable toward that pupil in a poorly answered question. There is no doubt whatever that, if a teacher has a favorable impression of a pupil, an examination poorly prepared for but properly bluffed will receive a fairly good mark. Ruch also makes the point that "when a pupil is confronted with a broad discussion question, he, in one sense, chooses the line of attack. He may be entirely ignorant of the importance of the question but for the time being he is general in charge. He can naively "misunderstnad" the question and write on some alien topic where his meagre store of knowledge can be turned to better advantage."[3] He can not very well do this with an objective test, however. The question is right before him and he must either answer the question given or not answer at all. McCall cites a case of masterfully evading the question asked.

1. Farwell, H. W. "The New Type Examination in Physics" School & Society 19; p.p.315-322
2. Ruch, G. M. The Objective or New Type Examination; p.p.109
3. Ruch, G. M. The Objective or New Type Examination; p.p.109

During a sixty minute examination of the traditional type, probably about half that time is spent in writing. The remainder of the time is spent in organizing and marshalling the facts. If a new type examination were given during the same period the pupil would be able to answer at least twice as many questions. This of course would mean that there would be a more extensive sampling. If a pupil is able to answer one question in a group, that is no indication that he is able to answer questions in some other group. ("Knowledge of a few items in a topic tends to guarantee knowledge of other items in the same topic more than knowledge of many items in one topic would tend to guarantee knowledge of items in some other topic."1) (Farwell on this same topic says, "A new type examination, according to my own understanding of the situation, may be of many varieties, but it must be one in which the student can quickly and unequivocally give reactions sufficient in number and kind to leave no great uncertainty as to the extent of his knowledge of the matter under consideration."2)

It would appear that the new type examination corrects a great many of the faults of the essay type of examination. The advantages of the new type tests are well summed up by Odell. ("The new type tests are, as is shown by a considerable mass of evidence, more reliable than traditional examinations, both because they secure better samplings of pupils ability and knowledge and because their scoring is relatively objective. Among the other advantages which they possess are that the pupils usually prefer then and are better satisfied with the marks they receive, emphasis is placed upon exact and accurate knowledge, knowledge of the subject being tested is measured without being mixed with ability in language, handwriting and so forth, speed can be measured when desired, scoring is easier, more thought is usually required in their construction, bluffing is more difficult, and two or more forms of practically equivalent difficulty can be prepared."3)

Which ever type of examination we choose to give, a great deal of time must be spent in its preparation if it is to be a good examination. One of the objections to the new type test has been that it required a much longer time in its preparation than the old type.

1. MacPhail, A. H. Quotation
2. Farwell, "The New Type Examination in Physics" School & Society 19; p.p.315-322
3. Odell, C. W. Traditional Examinations and New Type Tests

This very objection itself is really an argument in favor of the new type examination, because if a longer time is required, morecare will be given its formulation and consequently more information as to the students' ability will be gleaned from his answer. "The chief answer to this objection, however, is that whatever time is lost in construction will be saved in scoring, at least if the group of pupils tested is as large as twenty-five or thirty."[1] The more familiar a teacher becomes with the new type examination questions, the more quickly the test can be made out, but, nevertheless, it is an admitted fact that a great deal of time must be spent in preparation. The time gained in scoring, however, more than makes up for this loss.

There are a great many teachers who insist that the new type examination and the old type do not cover the same thing. Professor Paterson became suspicious of the statement that the two types were measuring different things and so conducted the following experiment. The first quarter, one old-type hour test and one new-type hour test together with an old-type hour test and one new-type hour final test were given. The old-type examinations reported were the old type at its best, prepared and scored in an almost ideal manner. The new type were correlated with the old type and the new type with the new type. ("The average of the reliability coefficients for the old type examinations is .52 as compared to an average of .67 for the new type examinations. It is apparent that the new type examinations are more reliable or self consistent, a fact which has been stressed by Wood, Ruch, Toops and others. Futhermore the average of the intercorrelations between the two types is .52. In view of the fact that the old type correlates with the new type as closely as it does with itself, there seems to be no escape from the conclusion that the two types of exams are measuring identical things."[2])

Professor Farwell states that the new type test is very useful in physics because, (1) It supplements the problem tests in a very desirable way, (2) It enables the quiz to cover more ground than the ordinary type covers, (3) It is more interesting and stimulating to the average student, (4) It can be graded much more quickly and uniformly, (5) It can be made as difficult as one desires, (6) used with the problem test it is more thorough than problems alone or problems

1. Odell, C. W. Educational Measurement in High School;p.p.14-15
2. Patterson, Donald G. "Do Old and New Type Examinations Measure the Same Thing?" School & Society 24; p.p.246-248

with the usual question.[1]

1. Wood, B. D. Measurement in Higher Education; p.215

CHAPTER V

ANALYSIS OF STANDARDIZED TESTS

Although physics was one of the first subjects in Science which interested test makers, we have no more nor no better tests in this subject than we have in any other science. The first physics tests which were published no longer fill the qualifications of a first class new-type examination. There were no norms to speak of, the reliability and validity were low, and the questions tended to be subjective. There has been published quite recently a number of examinations in physics that show the results of a quarter of century work in this field. Some of the older tests are obsolete. The writer will attempt in the following classification to list both the new and the old, and to point out the ones that are no longer of much use.

In giving the data on the following tests the writer has used, wherever possible, information that is given in the handbook which accompanies the test. In evaluating the tests he has first investigated as to the number of questions on each of the following topics (1) Mechanics (2) Heat (3) Sound (4) Light and (5) Electricity (including magnetism). This method seemed to be the only logical one to use to reach a basis of per centage composition of a physics course. The writer made the assumption that as these books were used by a majority of the teachers of physics in the United States, the course taught would follow, more or less, along the lines that were presented in the text, and about the same stress would be given to each division as there was space given to it in the book. He has then found the percentage of the total number of questions in each of the topics as compared to the number of questions in the examination. This percentage has been compared with the percentages

CHAPTER V

ANALYSIS OF EXAMINATION TESTS

found in the chapter on objectives of teaching physics. He has also found the total number of fact and thought questions in each test and also the percentage of each in every examination. In deciding which were thought items and which were fact, those that required a mere knowledge of a fact, theory or formula were classed as the latter, while those that required the use of those acquired facts in reasoning to a conclusion or working out a problem were considered as the former. No attempt has been made to do this for those tests that are no longer published, but a brief description of these has been given, in the Appendix. A table giving the various questions under each of the headings follows each of the tests that are still published. In discussing the work books and the instructional tests a list of the various topics has been given and has been compared with those covered in text books. The questions have not been listed as has been done in the other types of examinations.

In considering the minor criteria the writer has followed very closely the outline that has been given earlier in this thesis in the chapter on standardized tests.

If no information were available in the handbook or there were no handbook, any information that is given has been taken from some outside source. If such is the case, the reference has been given from which the information was taken.

This list is as complete as it could be made with the information available. If there are others that have not been listed, it is not because the writer intended a slight, but that they have not come to his attention.

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This list is as complete as it could be made with the information available. If there are others that have not been listed, it is not because the writer intended a slight, but that they have not come to his attention.

Name of Test: Starch's Physics Test
Author: Daniel Starch
Publisher: Daniel Starch, Cambridge, Mass.
Date of Publication: Not known

This test was produced by Daniel Starch while he was at the University of Wisconsin. It is one of the earlier objective tests in physics and consequently is now of little value.[2] Rich indicated that this test is now out of date.

By far the greater number of questions in this examination are fact items, requiring memorized material as will be seen by the chart at the end of this description. Most of the thought questions are merely problems requiring the manipulation of figures in memorized formula. Even if it were the intent of the teacher to test memorized material, this test has not enough questions in each section to warrant that use.

By consulting the table on percentage composition it will be seen that the divisions vary a great deal from the mean percentage composition of the eleven published texts. The percentage varies anywhere from three to five per cent in four of the cases, indicating that the proper distribution of questions is not presented in this examination.

After a careful study of five widely used text books in high school physics, it was discovered that one hundred and two topics were taken up by all of these. As a result seventy five completion questions were made out, which involved these ideas. They were divided into mechanics, heat, light, sound and magnetism, and electricity. They are constructed, supposedly, so that those sections might be given separately or together as a final examination.

1. Starch, D. Educational Measurements: p.p. 188-193

2. Rich, S. G. "The Available Tests for Results in Teaching Science" School Science and Mathematics 26: p.p. 845-852 1926

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1. Starch, D. Educational Measurements: p.p. 188-193
2. Rich, S. S. "The Available Tests for Results in Teaching Science" School Science and Mathematics 26: p.p. 845-852 1926

No further material on validity or reliability is given. There are standard scores furnished on the examination paper for each section of the examination.

In administering the test the directions given are inadequate. There are no directions on the examination paper to instruct the pupils what they are to do. There are no illustrations given. The pupils are allowed as much time as they reasonably need to complete the paper.

There is no scoring key furnished with this examination and the scoring is made difficult by the staggered responses to the questions. The score is the number of correct responses. There is no manual furnished with the test, and there are no duplicate forms.

The tests are published by Daniel Starch and orders should be addressed to him at 1374 Massachusetts Avenue, Cambridge, Mass. The cost is two cents per test and sample copies will be sent on request.

TABLE NO. 1

Thought and Fact Items in Starch's Physics Test

Total number of questions	75
Number of thought items	21
Percentage of thought items	28%
Number of fact items	54
Percentage of fact items	72%

TABLE NO. 2

Comparison of Starch's Physics Test with the Mean as to Percentage Composition of Eleven Text Books.

	Percentage Composition of Eleven Books	Test Items
Mechanics	33.64%	37.33%
Heat	14.53%	10.67%

No further material on validity or reliability is given.

There are standard scores furnished on the examination paper for each section of the examination.

In administering the test the directions given are inadequate. There are no directions on the examination paper to instruct the pupils what they are to do. There are no illustrations given. The pupils are allowed as much time as they reasonably need to complete the paper.

There is no scoring key furnished with this examination and the scoring is made difficult by the staggered responses to the questions. The score is the number of correct responses. There is no manual furnished with the test, and there are no duplicate forms.

The tests are published by Daniel Sheren and orders should be addressed to him at 1374 Massachusetts Avenue, Cambridge, Mass. The cost is two cents per test and sample copies will be sent on request.

TABLE NO. 1

Thought and Fact Items in Sterchi's Physics Test

Total number of questions	75
Number of thought items	21
Percentage of thought items	28%
Number of fact items	54
Percentage of fact items	72%

TABLE NO. 2

Comparison of Sterchi's Physics Test with the Mean as to Percentage Composition of Eleven Text Books.

	Percentage Composition of Eleven Books	Test Items
Mechanics	33.44%	37.33%
Heat	14.60%	10.67%

TABLE NO. 2 (Continued)

Sound	7.14%	12.00%
Electricity	31.10%	28.00%
Light	13.38%	12.00%

TABLE NO. 3

The Distribution of Thought and Fact Items According to Subject Matter in Starch's Physics Test.

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Absolute Unit of force	1				
Unit of work--erg	1				
Freely Falling bodies $s=\frac{1}{2}gt^2$	1				
Center of Gravity	1				
Law of Conservation of Energy	1				
Elastic limit	1				
Parallelogram of Forces	1				
Newton's Law of Gravitation	1				
Mechanical Advantage	1				
Newton's first Law	1				
Newton's 2nd Law of Motion	1				
Newton's 3rd Law " "	1				
Laws of the Pendulum	2				
Pascal's Law	1				
Specific Gravity	1				
Barometer--Uses	1				
Boyle's Law	1				
Pressure of Atmosphere	1				
Absolute Scale		1			
Calorie		1			
Transfer of Heat		1			
Coefficient of Expansion		1			
Work Units to Heat Units		1			
Radiant Energy		1			
Specific Heat		1			
Fundamental & Overtone			1		
Law of Strings			3		
Speed of Sound in air			1		
Frequency and Pitch			1		
Quality and Overtones			1		
Loudness & Amplitude			1		
Complimentary colors				1	
Index of Refractions				1	
Candle power--Photometor				1	
Speed of Light				1	
Dispersion--Spectrum				1	
Law of Reflection--Critical Angle				1	
Electromotive Force-voltage					1
Generators--Parts					1
Induction Coil					1
Transformer					1
Galvanometer					1
Ammeters					1
Amperes--definition					1
Ohms--definition					2
Laws of resistance					1
Volt--definition					2
Watt--definition					1

TABLE NO. 2 (Continued)

Sound	7.14%	12.00%
Electricity	31.10%	28.00%
Light	13.38%	12.00%

TABLE NO. 3

The Distribution of Thought and Fact Items According to Subject Matter in Storch's Physics Test.

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Absolute Unit of force	1				
Unit of work--erg	1				
Freely Falling bodies sqgt	1				
Center of Gravity	1				
Law of Conservation of Energy	1				
Elastic limit	1				
Parallelogram of Forces	1				
Newton's Law of Gravitation	1				
Mechanical Advantage	1				
Newton's First Law	1				
Newton's 2nd Law of Motion	1				
Newton's 3rd Law " "	1				
Laws of the Pendulum	2				
Pascal's Law	1				
Specific Gravity	1				
Barometer--Uses	1				
Boyle's Law	1				
Pressure of Atmosphere	1				
Absolute Scale		1			
Caloric		1			
Transfer of Heat		1			
Coefficient of Expansion		1			
Work Units to Heat Units		1			
Radiant Energy		1			
Specific Heat		1			
Fundamental & Overtone			1		
Law of Strings			3		
Speed of Sound in air			1		
Frequency and Pitch			1		
Quality and Overtones			1		
Loudness & Amplitude			1		
Complimentary colors				1	
Index of Refractions				1	
Candle power--Photometer				1	
Speed of Light				1	
Dispension--Spectrum				1	
Law of Reflection--Critical Angle				1	
Electromotive Force-voltage					1
Generators--Parts					1
Induction Coil					1
Transformer					1
Galvanometer					1
Ammeters					1
Amperes--definition					1
Ohms--definition					2
Laws of resistance					1
Volt--definition					2
Watt--definition					1

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Potential & Kinetic Energy	1				
Freely falling bodies	1				
Work in foot pounds	1				
Inclined plane	1				
Pullies	1				
Capillary Action	1				
Fluid pressure	1				
Specific Grav. of Float. body	1				
Surface tension	1				
Change from Cent. to Fahr.		1			
Beats problem			1		
Laws of Reflection of Light				1	
Candle power				1	
Lens-Focal Length				1	
Generators					1
Motors					1
Ohm's Law					1
Kilowatt-hour Problem					1
Condensor-Leydon Jar					1
Resistance--Mil-Ft. Method					1
Watts--Problem					1

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Potential & Kinetic Energy	1				
Freely falling bodies	1				
Work in foot pounds	1				
Inclined plane	1				
Pullies	1				
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Fluid pressure	1				
Specific Grav. of Flout. body	1				
Surface tension	1				
Change from Cent. to Fahr.		1			
Beats problem			1		
Laws of Reflection of Light				1	
Candle power				1	
Lens-Focal Length				1	
Generators					1
Motors					1
Ohm's Law					1
Kilowatt-hour Problem					1
Condenser-Leydon Jar					1
Resistance--Mil-Ft. Method					1
Watts--Problem					1

Name of Test: Jones' Union Physics Test
Author: F. T. Jones
Publisher: University Supply and Book Company
Date of Publication: 1918

These tests were compiled by F. T. Jones of the University School, Cleveland, Ohio. His purpose was to prepare some examinations that science teachers might have some means of knowing how the actual results their efforts produced compared with their ideals. His results were one of the first attempts to standardize a test in the field of high school physics.

This series consists of twenty seven tests, 6 on mechanics, 14 on heat, 2 on sound, 3 on electricity, and 2 on light. Hence, these tests are not apportioned to cover all the material that is covered in physics, nor do the number of questions on each division correspond to the percentage compositions of physics as it is usually taught.

These tests are of value only if a teacher wishes a diagnostic test and even then are of doubtful assistance due to the few topics covered under each head.

There are no fact items at all, the questions being of the problem type requiring the application of formulas that have been learned by the pupil.

The examination papers contain anywhere from 3 to 12 questions on each sheet, with the great majority containing five items. The time allowed for these papers ranges from $2\frac{1}{2}$ minutes to $12\frac{1}{2}$ minutes, although the author states that time may be allowed for the individual to finish his paper. When a percentile graph is figured, however, the author suggests that the graph be made on scores based on the time limit.

1. Jones, F. T. "Practice Exercises in Physics" School Review 26: p.p. 341-348 1918

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1. Jones, F. T. "Practice Exercises in Physics" School Review 26: p.p. 341-348 1918

There are no statements in regard to validity or reliability and no norms are presented. The author states that you should expect 80% of the class to stand 80 or above. The reliability is probably low because the tests are so short.

The examination is easy to administer. A sheet accompanies the tests giving directions. The questions are all problems with a space reserved for the answer. There are no directions or samples given to the pupil on the examination paper. There is no scoring key furnished with the tests but the answers may be written out and a home made scoring key used. The cost is 25 cents for the 21 tests.

TABLE NO. 4

Thought and Fact Items in Jones' Union Physics Tests

Total number of questions	153
Number of thought items	153
Percentage of thought items	100%
Number of fact items	0
Percentage of fact items	0%

TABLE NO. 5

Comparison of Percentage Composition of Jones' Union Physics Tests with the Mean Percentage Composition of Eleven Text Books.

	Percentage composition of eleven books	test items
Mechanics	33.64	17.65
Heat	14.53	59.48
Sound	7.14	6.54
Electricity	31.10	6.54
Light	13.38	9.80

TABLE NO. 6

The Distribution of Thought and Fact Items According to Subject Matter in Jones' Union Physics Tests.

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Resultant of forces	3				
Component force	1				
Inclined Plane	2				
Force	1				
Work in foot pounds	2				
Potential Energy	1				
Kinetic Energy	1				
Moment of Force	4				
Freely falling bodies	5				
Levers	1				
Pulley System	1				
Wheel and Axle	1				
Screw	1				
Horsepower	3				
Fahr. to Cent.		13			
Cent. to Fahr.		11			
Heat of Fusion		13			
Heat of Vaporization		13			
Specific Heat		39			
Heat and Work		5			
Coefficient of Expansion		3			
Boyles Law	1				
Charles Law		2			
Boyles and Charles Law		1			
Echo			1		
Speed			2		
Wave length of Sound			2		
Laws of Strings--Tension			1		
Laws of Strings--Length			2		
Sound over a closed pipe			1		
Sound over an open pipe			1		
Beats			1		
Candle power				2	
Mirrors--Radius of Curvature				1	
Lens--Focal Length				2	
Mirrors--Focal Length				1	
Illumination--Foot Candles				1	
Mirrors--Images				1	
Lens--Images				2	
Electrolysis					2
Heating Effect of a Current					2
Watts					2
Watts to Horsepower					1
Resistance in Series					1
Resistance in Parallel					1
Ohm's Law					4
Costs of Kilowatt Hour					1

TABLE NO. 8

The Distribution of Thought and Text Items According to Subject Matter in Jones' Union Physics Texts.

Thought Item	Mechanics	Heat	Sound	Light	Electricity
Resultant of Forces	8				
Component Force	1				
Inclined Plane	8				
Force	1				
Work in Foot Pounds	8				
Potential Energy	1				
Kinetic Energy	1				
Moment of Force	4				
Freely Falling Bodies	3				
Levers	1				
Pulley System	1				
Wheel and Axle	1				
Screw	1				
Horsepower	3				
Fahr. to Cent.		13			
Cent. to Fahr.		11			
Heat of Fusion		12			
Heat of Vaporization		13			
Specific Heat		30			
Heat and Work		8			
Coefficient of Expansion		3			
Boyles Law	1				
Charles Law		2			
Boyles and Charles Law		1			
Echo			1		
Speed			2		
Wave Length of Sound			2		
Laws of String--Tension			1		
Laws of String--Length			3		
Sound over a closed pipe			1		
Sound over an Open pipe			1		
Beats			1		
Candle power				2	
Mirrors--Radius of Curvature				1	
Lens--Focal Length				2	
Mirrors--Focal Length				1	
Illumination--Four Candles				1	
Mirrors--Images				1	
Lens--Images				2	
Electrolysis					2
Heating Effect of a Current					2
Watts					2
Watts to Horsepower					1
Resistance in Series					1
Resistance in Parallel					1
Ohm's Law					4
Costs of Kilowatt Hour					1

Name of Test: Camp's Iowa Physics Test
Author: H. L. Camp
Published: Public School Publishing Company
Date of Publication: 1920

The Iowa Physics Test is one of the earlier type tests and was first brought out to furnish additional means of measuring high school physics achievement. Camp set about to gather together a number of exercises and to evaluate them, so that the pupil in answering them would have to have a knowledge of the fundamental principles of physics and how to apply them. He arranged these exercises in tests, and had them administered to about 3500 Iowa high school students. From these papers he assigned values according to their difficulty. Three different series of tests were made up from these questions each series having two forms. The series were (A) Mechanics, (B) Heat, (C) Electricity and Magnetism.

These tests could not be used as an examination of the work covered in physics. In the first place there are only three divisions out of the five that are usually covered. Even if these lists were used as achievement tests on the three divisions given, they are probably too short to be of any value. This set of tests was one of the first to be published in this field and is no longer of much value. They have been far surpassed by later publications.

There is no mention of how the material used in these examinations was validated and neither is there any reliability given. As the tests are composed usually of eleven or twelve questions it would seem that they are not as reliable as some other published tests which are longer.

1. Camp, H. L. "Scales for Measuring Results of Physics Teaching" Journal of Educational Research Vol. 5:p.p. 400-405 1920

Name of Test: Camp's Iowa Physics Test
Author: E. L. Camp
Published: Public School Publishing Company
Date of Publication: 1920

The Iowa Physics Test is one of the earlier type tests and was first brought out to furnish additional means of measuring high school physics achievement. Camp set about to gather together a number of exercises and to evaluate them, so that the pupil in answering them would have to have a knowledge of the fundamental principles of physics and how to apply them. He arranged these exercises in tests and had them administered to about 3300 Iowa high school students. From these papers he assigned values according to their difficulty. Three different series of tests were made up from these questions each series having two forms. The series were (A) Mechanics, (B) Heat, (C) Electricity and Magnetism.

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1. Camp, E. L. "Scales for Measuring Results of Physics Teaching" Journal of Educational Research Vol. 3:p.p. 400-408 1920

The tests are practically self administering. Each question is complete in itself. The type of question is rather hard to classify, and really is question and answer with the answer being restricted to one correct response. Scoring sheets are provided and values for each question. There is a correct answer given and also a wrong answer. The sum of the value of the questions that are correct is the pupils score. This might have been greatly simplified by scoring the number of correct responses. The time allowed is 45 minutes for Heat and Mechanics and 40 minutes for Electricity and Magnetism.

No manual is provided with the examinations but a class record sheet is included. Norms are given on this class record sheet; but no distinction is made between the various forms, and the numbers upon which they are based is not given.

The norms are as follows:

Test	75 Percentile	Median	25 Percentile
Series A Mechanics	57.1	43.3	31.3
Series B Heat	57.6	42.7	28.9
Series C Electricity & Magnetism	67.8	50.7	34.0

These tests are sold in packages of 25 tests and 1 class record sheet, for fifty cents a package. A sample set of one form of each test may be had for 15c.

TABLE NO. 7

Thought and Fact Items in the Iowa Physics Test.

Total number of questions	34
Number of thought items	31
Percentage of thought items	91.18
Number of fact items	3
Percentage of fact items	8.82

No comparison on the percentage composition in each division

The tests are practically self administering. Each question is complete in itself. The type of question is rather hard to classify, and really is question and answer with the answer being restricted to one correct response. Scoring sheets are provided and values for each question. There is a correct answer given and also a wrong answer. The sum of the values of the questions that are correct is the pupils score. This might have been greatly simplified by scoring the number of correct responses. The time allowed is 40 minutes for Heat and Mechanics and 40 minutes for Electricity and Magnetism.

No manual is provided with the examinations but a class record sheet is included. Norms are given on this class record sheet; but no distinction is made between the various forms, and the numbers upon which they are based is not given.

The norms are as follows:

Test	75 Percentile	Median	25 Percentile
Series A Mechanics	87.1	43.3	31.3
Series B Heat	87.8	42.7	28.9
Series C Electricity & Magnetism	87.8	80.7	34.0

These tests are sold in packages of 25 tests and 1 class record sheet. For FIFTY cents a package. A sample set of one form of each test may be had for 10c.

TABLE NO. 7

Thought and Fact Items in the Iowa Physics Test.

Total number of questions	84
Number of thought items	31
Percentage of thought items	81.19
Number of fact items	3
Percentage of fact items	8.82

No comparison on the percentage composition in each division

as only mechanics, heat, and electricity are tested.

TABLE NO. 8

The Distribution of Thought and Fact Items According to Subject Matter in Iowa Physics Test.

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Work in Foot Pounds	1				
Vacuum	1				
Density	1				
Efficiency of Machines	1				
Moment of Force	1				
Boyles Law	1				
Wheel and Axle	1				
Lever	1				
Mechanical Adv.	1				
Newtons 2nd Law	1				
Pendulum	1				
Transference of Heat--Radiation		1			
Conductors of Heat		1			
Expansion Due to Heat		1			
Melting Point of Ice		1			
Calories		1			
Change from Fahr. to Cent.		1			
Charles Law		1			
Specific Heat		2			
Mech. Equivalent of Heat		1			
Conductors of Electricity					1
Attraction of Like Charges					1
Electric Cells					1
Static Electricity					1
Volt Meter					1
Galvanometer					1
Ohm's Law					1
Amperes					1
Electrolysis					1
Resistance					1
Fact Items					
Barometer	1				
Transference of Heat--Convection		1			
Volt					1

Name of Test: Thurstone's Vocational Guidance Tests: Physics:
Author: L. L. Thurstone
Publisher: World Book Company
Date of Publication: 1922

This set of tests is the work of L. L. Thurstone of the Carnegie Institute of Technology. This battery consists of five tests; Arithmetic, Algebra, Geometry, Physics, and Technical Information. The purpose of these tests is prognostic, and they were made up to conform with a resolution passed by the Society for the Promotion of Engineering Education. The recomendations of the Society were that as a matter of experiment and research, psychological, "objective", "trade" or other similar tests be given to all students after admission to engineering courses of study and that ratings thus obtained be compared with their subsequent scholastic progress. The test that merits our consideration here is the one onphysics. This examination consists of twenty five problems on the application of physics principles, generally of engineering interest.

When this test is compared with the mean of eleven text books as to percentage composition it is seen that divisions do not compare very well. Far too much stress is laid on mechanics and not nearly enough on electricity. The scattering of the questions is not very good. There are some topics that have two questions concerning them, which is too many when we consider that the test has only twenty five questions in all. If these faults were not present, this test might well be used in high schools to determine whether a pupil can apply the physics fundamentals learned; and, also, might be used as a criteria for admission to engineering schools. The questions themselves do not differ materially from other objective examinations in physics.

Full directions are given for administering the test in the manual, and directions are also given to the student on the examination sheet

itself. The taking of the examination presents no difficulty because the items are all of the problem type. The time given for the test is 30 minutes, bringing the question of speed into the results.

Scoring keys properly spaced are supplied for each examination. Each correct response counts one point toward the score, no partial credit being given. One point is also deducted for failure to put all the answers in the proper spaces.

Several tables are given to aid interpreting the test scores. The norms for each test are given as per centile ranks based on the results of 6883 engineering freshmen in 43 representative engineering colleges. Another table shows the average score made in each test with the name of the school for 6610 cases. Table 3 shows the correlations between the test scores and first year engineering scholarship, and between high school standing and first year engineering scholarship. In physics the correlation between the test and first year engineering scholarship is +.34 which is practically the same as high school marks and first year engineering scholarship which is +.33. The intercorrelation between Physics Test with the Arithmetic Test is +.56, with the Algebra Test +.38, with the Geometry Test +.40, with the Technical Information Test +.46 and with the Psychological Examination +.34.

There are no duplicate forms and no information is given as to how the tests were constructed nor is there any information on the reliability of the tests.

The cost of this test is $1.00, net, for a package of 25 tests with key, and class record. Each of the five tests comes in a separate package at the same price. The manual of directions is 20 cents. A specimen set consisting of one of each of the tests, with key, record sheet, and manual may be had for fifty cents.

itself. The taking of the examination presents no difficulty because the items are all of the problem type. The time given for the test is 50 minutes, bringing the question of speed into the results.

Scoring keys properly spaced are supplied for each examination. Each correct response counts one point toward the score, no partial credit being given. One point is also deducted for failure to put all the answers in the proper spaces.

Several tables are given to aid interpreting the test scores. The norms for each test are given as per centile ranks based on the results of 6880 engineering freshmen in 43 representative engineering colleges. Another table shows the average score made in each test with the name of the school for 6810 cases. Table 3 shows the correlations between the test scores and first year engineering scholarship, and between high school standing and first year engineering scholarship. In practice the correlation between the test and first year engineering scholarship is .54 which is practically the same as high school marks and first year engineering scholarship which is +.55. The intercorrelation between fluidics Test with the Arithmetic Test is +.50, with the Algebra Test +.56, with the Geometry Test +.40, with the Technical Information Test +.46 and with the Psychological Examination +.34.

There are no duplicate forms and no information is given as to how the tests were constructed nor is there any information on the reliability of the tests.

The cost of this test is $1.00, net, for a package of 25 tests with key, and class record. Each of the five tests comes in a separate package at the same price. The manual of directions is 50 cents. A specimen set consisting of one of each of the tests, with key, record sheet, and manual may be had for fifty cents.

TABLE NO. 9

Thought and Fact Items in Thurstones' Vocational Guidance Tests

Physics:

Total number of questions	25
Number of thought items	25
Percentage of thought items	100
Number of fact items	00
Percentage of fact items	0

TABLE NO. 10

Comparison of Percentage Composition of Thurstones Test in Physics with the Mean Percentage Composition of Eleven Text Books.

	percentage composition of text books	composition of Physics Tests
Mechanics	33.64	60.
Heat	14.53	4.
Sound	7.14	4.
Electricity	31.10	20
Light	13.38	12

TABLE NO. 11

The Distribution of Thought and Fact Items According to Subject Matter in Thurstone's Vocational Guidance Tests.

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Forces--Chain Weakest Link	1				
Power W=EI					1
Work FxS	1				
Angular Velocity	1				
Specific Gravity-Submerged	1				
Speed of Sound V=NL			1		
Hydraulic Press.	1				
Image in a Convex Lens				2	
Motion $s\frac{1}{2}$ at^2	1				
Principle of Moments	1				
Law of Reflection				1	
Fluid Pressure	1				
Laws of Resistance					2
Ohm's Law					2
Mixtures		1			
Boyles Law	1				
Resultant of Forces	2				
Levers	1				
Fluid Force	1				
Pullies	1				
Hookes' Law	1				

TABLE NO. 9

Thought and Fact Items in Thurstones' Vocational Guidance Tests

Physics:

Total number of questions	25
Number of thought items	25
Percentage of thought items	100
Number of fact items	00
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Light	13.38	12

TABLE NO. 11

The Distribution of Thought and Fact Items According to Subject Matter in Thurstone's Vocational Guidance Tests.

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Forces--Chain Weakest Link	1				
Power W=LT					1
Work FxS	1				
Angular Velocity	1				
Specific Gravity-Submerged	1				
Speed of Sound V=NL			1		
Hydraulic Press.	1				
Image in a Convex Lens				2	
Motion s_2 at^2	1				
Principle of Moments	1				
Law of Reflection				1	
Fluid Pressure	1				
Laws of Resistance				1	
Ohm's Law				1	
Mixtures		1			
Boyles Law	1				
Resultant of Forces	2				
Levers	1				
Fluid Force	1				
Pullies	1				
Hookes' Law	1				

Name of Test: Iowa Placement Examinations: Physics
Author: G. D. Stoddard
C. J. Lapp
Publisher: Bureau of Educational Research & Service
Date of Publication: 1925

This series of tests in physics was produced by G. D. Stoddard and C. J. Lapp under the direction of C. E. Seashore and G. M. Ruch and was published at the University of Iowa. The entire set consists of tests in Chemistry Aptitude, English Training, Foreign Language Aptitude, French Training, Spanish Training, Mathematics Aptitude, Mathematics Training, Physics Aptitude and Physics Training. The last two on physics are the ones that concern us most vitally. There are two forms of each examination. The Physics Aptitude is designed to measure mental abilities which contribute to success in physics, while the Physics Training is designed to measure previous training which is considered as contributory to future success in physics. The latter assumes that at least one course has been taken previously in physics.

The test in Physics Training might well serve as a final examination in physics in high school. The material generally taught in physics is well covered by the examination. The percentage composition as compared with the mean of percentage composition of eleven text books shapes up very well. The greatest discrepancies are in electricity and light. The length of the test assures a fairly high reliability, while the percentage of thought and fact items might fit in well with a test the aim of which is to test achievement.

The test items were made out under the following conditions: 1. The items were presented to experienced instructors in the subject for judgment, 2. High School and College text books were examined, 3. Recommendations of committees on curricula were studied, 4. Results

Name of Test:
Author:

Publisher:
Date of Publication:

of previous research in standardizing content material were consulted, and 5. Statistical comparisons of test elements with subsequent semester success in the subject were made. Nine colleges cooperated in the experimental work and reported 10,291 scores and grades. On the basis of these results the series were revised. The reliability of the Physics Training form A is given as .85 based on 100 cases.[1] There is no reliability coefficient furnished for Physics Training form B nor for either form of the Physics Aptitude Test.

Physics Aptitude, Series P A 1, Revised: Part I, consists of twenty five items on the simple arithmetic of physics. Part II consists of three paragraphs taken from a college physics text book. Under each paragraph are listed ten true-false items, the answer for which may be obtained from the paragraph. Part III A consists of five number series completion questions while part III B consists of fifteen logical conclusion questions controlled by a true-false response. Part IV consists of fifty true-false questions on general information concerning physics, which might have been gained through general reading.

Physics Training Series P T I, Revised: Part I consists of forty completion questions on the fundamentals of Physics, Part II consists of fifty true-false items based, also, on the fundamentals of physics, Part III consists of five simple recall on formulas, eight completion on physics information, and seven simple recall on discoverer of the law stated. Part IV consists of fifteen physics problems.

The administration of this test is comparatively simple. The directions given in the manual are adequate and the directions to pupils, together with samples where needed, are printed on the

1. Stoddard, G. D. "The Iowa Placement Examinations", University of Iowa Studies. First Series, No. 99/3: No. 2 1925

examination paper. As these examinations are given to students of college level, there is no difficulty involved. The time required for these examinations is between 43 and 45 minutes which is ample time in a college period of one hour.

A scoring key is furnished for each examination. The key is not spaced to fit the examination paper and the authors suggest that they be copied on to strips of card properly spaced. Part I of physics training might be improved by not staggering the responses. No partial credits are given. Each part of the examination is weighted, the amount being given on each section of the examination.

Norms are given for Form A in both Physics Training and Aptitude but not for Form B in Physics Training. Physics Aptitude Form A is based on 3126 cases, Physics Training Form A on 1274 cases, and Physics Aptitude Form B, 494 cases. The norms are given in quartiles with the standard deviation.

The authors give several uses for these examinations. (1) To afford a basis for prediction of the character of work each student will do in college.[1] The correlation between the results on physics scores and corresponding first semester college grades is, 1st series .50 and second series .55, (2) To aid in selecting and admitting pupils, (3) To serve as an entrance examination, (4) To section classes for instructional purposes on the basis of mental ability, (5) To assist in deciding how much work a student can carry, (6) To deal with students not well oriented in college work, (7) To give scientific aid in vocational guidance and placement, (8) To enable comparative studies of intellectual levels as between classes, colleges, and college years, (9) To furnish a basis for diagnosis of class weaknesses, (10) to enable high schools and preparatory

1. Ruch and Stoddard, Tests and Measurements in High School Instruction: p. 208.

schools to survey their seniors or graduates in order to determine probable fitness for collegiate studies.

The price of these examinations is $3.50 per hundred, including manual of directions and key. Copies of each of the examinations with manual and key cost five cents each.

TABLE NO. 12

Thought and Fact Items in Iowa Placement Examinations

Series PT. Revised A.

Total number of questions	125
Number of thought items	46
Percentage of thought items	36.8%
Number of fact items	79
Percentage of fact items	63.2%

TABLE NO. 13

Comparison of Percentage Composition of Iowa Placement Examinations in Physics with the Mean Percentage Composition of Eleven Text Books

	Percentage text books	Composition of Physics Test
Mechanics	33.64	36.00%
Heat	14.53	12.80%
Sound	7.14	6.40%
Electricity	31.10	34.40%
Light	13.38	10.40%

TABLE NO. 14

The Distribution of Thought and Fact Items According to Subject Matter in Iowa Placement Examinations.

Series P T I Revised A Thought Items	Mechanics	Heat	Sound	Light	Electricity
Electrical Conductors					1
Electric Fuses					1
Efficiency of a Machine	1				
Poles of a Magnet					2
Temperature Scales		1			
Fahrenheit to Centigrade		1			
Kinetic Energy	2				
Refraction of Light				1	

Series P T I Revised A.

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Aneroid Barometer	2				
Heating Effect of an Electric Current					1
T ransference of Heat--Convection		1			
Levers	2				
Compass					1
Source of Energy--Sun	1				
Dew Point		1			
Line Losses Elec. Current					1
Earth Magnetic Field					1
Positive Electricity					1
Conductors of Electricity					1
Expansion due to Heat		1			
Fluid Pressure	3				
Pull of Gravity	1				
Specific Gravity	2				
Surface Tension	1				
Melting Point		1			
X-Rays					1
Static Electricity					1
Air Pressure--Application	1				
Potential Energy	1				
Specific Heat	1				
Motion	1				
Echoes			1		
Boyles Law	1				
V=NL Frequency			1		
Efficiency of a Machine	1				
Gravitation	1				
Watts					1
Cost of K W H					1
Photomotor				1	

Series P T I Revised A.

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Aneroid Barometer	2				
Heating Effect of an Electric Current					1
Transference of Heat--Convection		1			
Levers	2				
Compass					1
Source of Energy--Sun	1				
Dew Point		1			
Line Losses Elec. Current					1
Earth Magnetic Field					1
Positive Electricity					1
Conductors of Electricity					1
Expansion due to Heat		1			
Fluid Pressure	3				
Pull of Gravity	1				
Specific Gravity	2				
Surface Tension	1				
Melting Point		1			
X-Rays					1
Static Electricity					1
Air Pressure--Application	1				
Potential Energy	1				
Specific Heat	1				
Motion	1				
Echoes			1		
Boyles Law	1				
V=NL Frequency			1		
Efficiency of a Machine	1				
Gravitation	1				
Watts					1
Cost of K W H					1
Photometer				1	

Iowa Placement
Series P T I Revised A.

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Kilowatt					1
Velocity of Sound			1		
Metric to English	1				
Electrolysis					2
X-Rays					1
Watts and Horsepower					1
Complimentary Color				1	
Power	2				
Laws of Resistance					2
Sound as Wave Motion			1		
Coulombs					1
Acceleration of a Body	1				
Absorbtion of Heat		1			
Laws of Reflection				1	
Transparency				1	
Transference of Heat--Radiation		1			
Dynamos--Generators					1
Electron Theory					3
Horsepower	1				
Energy	1				
Volt					1
Characteristic--Quality			1		
Heat of Fusion		1			
Density	1				
Resistance in Series					1
Melting Point		1			
Action of water above and below 4 C		1			
Transference of Heat--Conduction		1			
Propagation of Light				1	
Newtons Third Law--Reaction	1				
Static Electricity					1
Ductility	1				
Condensors					1
Speed of Light				1	
Molecular Theory	1				
Mixtures		1			
Resultant of Forces	1				
Radio					1
Efficiency of a Machine	1				
Galvanometer					1
Intensity of Sound			1		
Intensity of Light--Ft. Candles				1	
Specific Heat		1			
Characteristics--Pitch			1		
Radioactivity					1
Wheatstone Bridge					1
Ionization					1
Wave Motions of Light				1	
Spectra				1	
Vacuum Tubes					1
Cells in Parallel					1
Heat of Vaporization		1			
Index of Refraction				1	
Interference of Sound			1		

Iowa Placement
Series F & I Revised A.

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Kilowatt					1
Velocity of Sound			1		
Metric to English	1				
Electrolysis					2
X-Rays					1
Watts and Horsepower					1
Complimentary Color				1	
Power	2				
Laws of Resistance					2
Sound as Wave Motion			1		
Coulombs					1
Acceleration of a Body	1				
Absorption of Heat		1			
Laws of Reflection				1	
Transparency				1	
Transference of Heat--Radiation		1			
Dynamos--Generators					1
Electron Theory					3
Horsepower	1				
Energy	1				
Volt					1
Characteristic--Quality			1		
Heat of Fusion		1			
Density	1				
Resistance in Series					1
Melting Point		1			
Action of water above and below 4 C		1			
Transference of Heat--Conduction		1			
Propagation of Light				1	
Newtons Third Law--Reaction	1				
Static Electricity					1
Ductility	1				
Condensers					1
Speed of Light				1	
Molecular Theory	1				
Mixtures		1			
Resultant of Forces	1				
Radio					1
Efficiency of a Machine	1				
Galvanometer					1
Intensity of Sound			1		
Intensity of Light--Ft. Candles				1	
Specific Heat		1			
Characteristics--Pitch			1		
Radioactivity					1
Wheatstone Bridge					1
Ionization					1
Wave Motions of Light				1	
Spectra				1	
Vacuum Tubes					1
Cells in Parallel					1
Heat of Vaporization		1			
Index of Refraction				1	
Interference of Sound			1		

Iowa Placement
Series P T I Revised A.

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Mechanical Advantage	1				
Friction	1				
Boyles Law	1				
Newtons Second Law & Momentum	1				
Kinetic Energy	1				
Ohms Law					1
Electric Cells--Dry					1
Voltmeter					1
Pin Hole Camera				1	
Ammeter					1
Barometer	1				
Images in a Curved Mirror				1	
Use of Vernier	1				
Use of Protractor	1				
Archimedes Principle	1				
Pascals Law	1				
Charles Law		1			
Hookes Law	1				
Lenz's Law					1
Heating Effect of a Current					1

Name of Test: The Hughes Physics Scales
Author: J. J. Hughes
Publisher: Public School Publishing Company
Date of Publication: 1926

There are four forms of this test, two to measure information and two to measure thought. The questions on the latter tests were chosen on the basis of the reasoning processes brought forth in their solution. There are thirty questions on each test, the questions being mainly of the brief answer type with a few multiple response questions mixed in.

These tests are not of much value at the present time. The weight of the questions is a factor against them. The percentage composition of the tests is not well balanced. In some, electricity is stressed; while in others, the emphasis is on mechanics. Even if the two divisions of each form are given, thus including fact and thought items, the test is not balanced as it should be. The combining of the two tests would increase the reliability, but this is not the best test that is published today.

The tests were prepared after a careful questionnaire study of what is taught, and by analysis of the various texts in use. The most emphasized material in the course as revealed in the two studies was then chosen as the basis for the choice of items which make up the test. Preliminary tests consisting of 154 items were given to a large number of high school pupils who had completed the year's course in high school physics. On the basis of these scores computed from the answers of 1300 or more pupils, each test was made by selecting from the 154 items 30 items of such difficulty that each succeeding item differs in difficulty from the one preceding it by 0.1 probable error.

These scales may be used (a) to measure the progress of the pupils, (b) to diagnose the difficulties of the pupils, (c) for

ranking, grading and classifying pupils, and (d) for college classifications. The author recommends that a scale of little difficulty be given at the beginning of the course before any instruction has been given the pupils. Later in the course the same scale or different scales may be again given. Since the scale score on one scale is directly comparable to the scale score on any of the others, the progress of the pupil is measured by the increase in his score.

The administration presents no difficulty because the directions are given fully on the first page of each test booklet. There is also material to be read to the class printed in the leaflet sent with the tests. The time required for the examinations is twenty minutes for the information scale and thirty seven minutes for the thought scale. The correct answers for each test are furnished, but are not on a scoring key. The process of scoring the papers is somewhat of a time consuming process. The system used is one originated by Van Wagenen[1] and uses groups of items rather than the individual questions. There is some question as to the use of this method of computing the scores. Powers shows that the two methods of marking correlate .98.[2] Ruch & Meyer say that "the Hughes Scale would gain somewhat in validity if scored simply 'Number Right' "[3]. They also say in the same article that "more reliable results will probably be secured if the weighting scheme of the Hughes Scale is abandoned in favor of the simpler 'Number Right' method of scoring." Spencer and Douglas also came to the conclusion that the weighted and un-

1. Monroe, W. S. Theory of Educational Measurement: p.p. 118-131
2. Symonds, P. M. Measurement in Secondary Education: p. 140
3. Ruch, G. M. & Meyer, S. H. "Comparitive Merits of Physics Tests," School Science and Mathematics 31: p.p. 676-680 1931

weighted scores correlated so highly that weighting was unimportant.

The median score of each of the scales, the first quartile and the third quartile are given. No reliability is mentioned by the author in his booklet which accompanies the test.

Each of the tests come in a separate package with twenty-five tests in a package at fifty cents a package. A sample set of all four scales with a booklet on each test may be obtained for fifteen cents.

TABLE NO. 15

Thought and Fact Items in Hughes Physics Scales

	Inf. R. Div. 1	Thought R Div. 1	Inf. S. Div. 2	Thought S. Div. 2
Total number of questions	30	30	30	30
Number of thought items	0	30	0	30
Percentage of thought items	0	100	0	100
Number of fact items	30	0	30	0
Percentage of fact items	100	0	100	0

TABLE NO. 16

Comparison of Percentage Composition of Hughes Physics Scales with the Mean Percentage Composition of Eleven Text Books.

	Text Books	Inf. R. Div. 1	Thought R. Div. 1	Comb. T & I	Inf. S Div. 2	Thought Div. 2	Com. T & I
Mechanics	33.64	23.33	46.67	35.00	20.0	26.67	23.33
Heat	14.53	6.67	10.00	8.33	6.67	13.33	10.00
Sound	7.14	10.00	10.00	10.00	13.33	13.33	16.67
Electricity	31.10	50.00	23.33	36.67	43.33	33.33	38.38
Light	13.38	10.00	10.00	10.00	16.67	13.33	15.00

1. Ruch, G. M. Meyer, S. H. "Comparative Merits of Physics Tests," School Science and Mathematics 31: p.p. 676-680 1931

TABLE NO. 17

The Distribution of Thought and Fact Items According to Subject Matter in Hughes Physics Scale

Information R Division 1	Mechanics	Heat	Sound	Light	Electricity
No. of Poles of Magnet					1
Relation of Resistance to Length					1
Electroscope					1
Generator					3
Gravity	1				
G = VT	1				
V = NL	1				
Temp. on C°Scale of Boiling H_2O		1			
Velocity of Light				1	
Centrifugal Force	1				
Electro-plating					1
Carburator	1				
Calorie		1			
Volt					1
W = IE					1
Amt. of Current					1
Type of Cell					1
Unit of Vol. in Metric	1				
Magnetic Induction					1
Shadow				1	
I = E/R					1
Photometer				1	
Electro-magnet					1
Interference of Sound			1		
Molecular Theory	1				
Sound Beats			1		
Name of note of string Vibrating in Single Loop			1		
Ray Produced When Cathode Ray Strikes Solid Object					1

Thought R, Division 1					
V = NL			1		
D = M/V	1				
Radiation		1			
Momentum	1				
Angle of Reflection				1	
Calorie		1			
Work	1				
Magnetism					1
Velocity of Sound			1		
Force	1				
Weight	1				
Distance from Image				1	
Density	1				
Reduction of Internal Resistance					1
Capillary Action	1				
Efficiency	1				
Resultant of Forces	1				

TABLE NO. IV

The Distribution of Thought and Fact Items According to Subject Matter in Hughes Physics Books

Information R Division 1	Mechanics	Heat	Sound	Light	Electricity
No. of Poles of Magnet					1
Relation of Resistance to Length					1
Electroscope					1
Generator					3
Gravity	1				
Q = VI	1				
V = RI	1				
Temp. on C'Scale of Boiling H_2O		1			
Velocity of Light				1	
Centrifugal Force	1				
Electro-plating					1
Carburetor	1				
Calorie		1			
Volt					1
W = IV					1
Amt. of Current					1
Type of Cell					1
Unit of Vol. in Metric	1				
Magnetic Induction					1
Shadow			1		
I = E/R					1
Photometer				1	
Electro-magnet					1
Interference of Sound			1		
Molecular Theory	1				
Sound Waves			1		
Rate of rate of string					
Vibrating in Single Loop	1				
Ray Produced When Cathode Ray					
Strikes Solid Object					1

Thought R. Division 1

V = RI				1	
D = M/V	1				
Radiation		1			
Momentum	1				
Angle of Reflection				1	
Calorie		1			
Work	1				
Magnetism					1
Velocity of Sound			1		
Force	1				
Weight	1				
Distance from Image				1	
Density	1				
Reduction of Internal Resistance					1
Capillary Action	1				
Efficiency	1				
Resultant of Forces	1				

Hughes Physics Scales

Thought R, Division 1	Mechanics	Heat	Sound	Light	Electricity
Sound			1		
Power					1
Current					1
Heat Transference		1			
Inclined Plane	1				
Generator					1
Archimedes Principle	1				
Centrifugal Force	1				
Mirror				1	
Resultant	1				
Heat due to Electric Current					1
Force of Attraction					1
Foot pounds of Work	1				

Information S, Division 2					
Static electricity					1
Angle of reflection				1	
Good non-conductor elec.					1
Transformer					1
W = I E					1
Amt. of Current					1
Refraction				1	
Inertia	1				
Velocity of Sound			1		
Electric cell					1
Centrifugal force	1				
Differential	1				
Magnetic induction					1
Lens for nearsightedness				1	
Interferences of sound			1		
Production of elec, by induction					1
Ductility	1				
Note of string vibrating in Single loop			1		
Ray produced when cathode ray Strikes solid object					1
Index of refraction				1	
Angle of deviation					1
Smallest known electrical charge					1
Change ^{o}C to ^{o}F.		1			
Type wound motor that gains speed indef.					1
Vibration ratios of notes			1		
Decrease in resultant pressure					1
Law or principle explaining height Balloon will rise	1				
Spectrum produced by incandescent Solid or liquid				1	
Temp. of water vapor condensation		1			

Hughes Physics Scales Thought: S Division 2.	Mechanics	Heat	Sound	Light	Electricity
Attraction of gravity	1				
Mirror (distance from image)				1	
Density	1				
Mechanical advantage	2				
Magnetism					1
Resultant	1				
Transfering from English to Metric system	1				
Heat		1			
Result of two complementary colors				1	
Current					3
Intensity of sound			1		
Momentum	1				
Frequency of vibration			2		
Resistance of wire					1
Transfering Centigrade to Fahrenheit		1			
Force of Attraction					1
Vibration ratios of notes			1		
Sum of resistances in parallel					1
Fall of potential with change in Resistance					1
Induced current					2
Coefficient of cubical expansion Of glass		1			
Refraction				1	
Molecular theory	1				
Expansion due to heat		1			
Transverse wave motion				1	

Name of Test: Columbia Research Bureau Physics Test
Authors: H. W. Farwell
Ben. D. Wood
Publishers: World Book Company
Date of Publication: 1926

This test is the results of the work of H. W. Farwell and Ben. D. Wood of Columbia University. There are two forms of the test of 144 questions each, and it is designed as an achievement test to be used at the end of a high school course in physics, or as a test for placement in college physics. According to the authors the tests may be used (1) as a partial or total basis for assigning high school grades in physics or grades at the end of elementary courses in college physics, (2) in establishing uniform or comparable standards for admission to college with credit in physics, (3) in adjusting teaching emphasis on various topics in physics, (4) in the educational and vocational guidance of students, and (5) in promoting educational research.

The test covers material that is usually found in high school and elementary college physics text books, and also the requirements of the College Entrance Examination Board. The tests would evidently be good to use for a final examination in physics. There is a judicious scattering of thought and fact items and the percentage composition compares very favorably with the mean percentage composition of eleven text books. This is one of the best tests in physics published up to the present time.

There are 144 true-false questions in each examination, arranged in approximate order of difficulty from easiest to most difficult. They include both information and reasoning questions, with a preponderance of weight on reasoning and problem solving. The problem solving is accomplished in an unusual way. One of the cases taken from form A of the test will serve as an illustration. Problem

Name of Test: Columbia Research Bureau Physics Test
Author: B. E. Purwell
Ben. D. Wood
Publishers: World Book Company
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(for statement 8 to 11) A rectangular box whose base is 20 cm. by 50 cm, is set horizontally and filled to a depth of 10 cm. with water of density 1 gr. per cu. cm.

8. The weight of the water in the box is 10 kilograms. ( )

9. The water pressure on the bottom of the box can be found by dividing the weight of the water by the area of the bottom. ( )

10. To double the pressure on the bottom due to the water, pour into the box enough water to make the depth 20 cm. ( )

11. The water pressure on the bottom of the box is twice that on the side at the same distance below the water surface. ( )

The tests were derived by first making out two 164 questions tests after years of experimenting with long tests of true-false types of questions in physics. These two lists were drawn up so as to be as nearly equivalent as possible and administered to a group of pupils. Each question was studied individually with respect to validity and all questions that did not differentiate significantly between good and poor students were discarded. There remained 144 questions on each test. After being administered to the same group of pupils, they were found to be almost exactly equivalent, form B 2 or 3 points more difficult than form A.

The correlation of the test with college marks in physics is about .70 based on 300 cases; and with the old-type part of the New York State Regents Examinations in Physics about .60 based on 14,081 cases. This latter figure is low but is comparatively high when we consider the low reliability of a ninety minute old-type test.

The reliability coefficient estimated by the Spearman-Brown formula is about .90 based on 300 students entering an eastern college with credit for high school physics. The reliability co-

(for statement 8 to 11) A rectangular box whose base is 30 cm. by
30 cm. is set horizontally and filled to a depth of 10 cm. with
water of density 1 gr. per cu. cm.

8. The weight of the water in the box is 10 kilograms. ( )

9. The water pressure on the bottom of the box can be
found by dividing the weight of the water by the
area of the bottom. ( )

10. To double the pressure on the bottom due to the wa-
ter, pour into the box enough water to make the
depth 20 cm. ( )

11. The water pressure on the bottom of the box is
twice that on the side at the same distance below
the water surface. ( )

The tests were derived by first making out two 164 questions
tests after years of experimenting with long tests of true-false
types of questions in physics. These two lists were drawn up so
as to be as nearly equivalent as possible and administered to a
group of pupils. Each question was studied individually with
respect to validity and all questions that did not differentiate
significantly between good and poor students were discarded. There
remained 164 questions on each test. After being administered to
the same group of pupils, they were found to be almost exactly
equivalent. Form B 2 or 3 points more difficult than Form A.

The correlation of the test with college marks in physics is
about .70 based on 300 cases; and with the old-type part of the
New York State Regents Examinations in Physics about .80 based
on 14,001 cases. This latter figure is low but is comparatively
high when we consider the low reliability of a ninety minute old-
type test.

The reliability coefficient estimated by the Spearman-Brown
formula is about .90 based on 300 students entering an eastern
college with credit for high school physics. The reliability co-

efficient based on random sampling of 575 New York State high school students taking the Regents Examinations in June 1925 is .86. This probably would have been higher except that both the pupils and teachers might have been unfamiliar with this type of examination.

There are directions for the pupils given on the examination papers, but there are no illustrations given. Directions for administering the test are given in the manual of instructions. As the questions are all of the true-false type, examples probably would not benefit the test very much. The test should, according to the authors, require 75 minutes but 90 minutes is allowed and then the paper is collected. This length of time probably handicaps its use in some schools.

The scoring is by what the authors call a "block" key. When the key is placed in one position only plus signs should be showing, while, if placed in another, only zero signs should appear. The test is highly objective and may be scored by a clerk or even by juniors and seniors in high school. They can be scored very rapidly. The authors state that they have scored at the rate of 43 papers an hour per person. The score on the test is the number of right responses minus the number of wrong responses.

Norms based on 14,081 cases are given on a per centile graph, and the percentile curve is given. They also give a method of transferring the ranks on papers into letter grades. Teachers unfamiliar with statistical methods will find this of great convenience.

The tests are put up in packages of 25 with Manual of Directions, key and class record and the cost is $1.25 net for either form. A speciman set, including a copy of Form A and a copy of Form B, key, class record and manual of direction costs 20 cents post paid.

TABLE NO. 18

Thought and Fact Items in Columbia Research Bureau Physics Test

	Form A	Form B
Total number of questions	144	144
Number of Thought Items	129	131
Percentage of thought items	89.58%	90.97%
Number of fact items	15	13
Percentage of fact items	10.42%	9.03

TABLE NO.19

Comparison of Percentage Composition of Columbia Research Bureau Physics Test with the Mean as to Percentage Composition of Eleven Text Books.

	Percentage of books	Composition of tests Form A.	Form B.	Composite Table
Mechanics	33.64	35.42	34.72	35.07
Heat	14.53	13.47	13.89	13.68
Sound	7.14	7.64	6.25	6.95
Electricity	31.10	29.86	28.47	29.17
Light	13.38	13.89	16.67	15.28

TABLE NO. 20

The Distribution of Thought and Fact Items According to Subject Matter in Columbia Research Bureau Physics Test.

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Pascals Law	4				
Transfer from Met. To Eng., Eng. to Met. System	2				
Pressure due to depth in a fluid	7				
Sideways pressure due to fluid	5				
Weight of a volume of water	1				
Archimedes Principle (submerged)	6				
Archimedes Principle (Floating Bodies	5				
Specific Gravity	4				
Mercury Barometer	2				
Lift Pumps	2				
Sum of two Forces	4				
Boyles Law	2				

Columbia Research Bureau
Physics Test

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Equilibrium	2				
Freely falling bodies	2				
Energy--Potential vs Kinetic	3				
Energy--Kinetic	2				
Energy--Potential					
Power rate of work of machines	2				
Mechanical Adv. of a machine	2				
Horsepower	2				
Efficiency of a machine	3				
Friction	1				
Moment of force	12				
Forces	2				
Forces at a fulcrum	4				
Principle of moments	1				
Curvilinear motion					
Centrifugal force	2				
Barometer (In general)	1				
Change from C scale to F. scale		2			
Transference of Heat--Insulation		1			
Newton, Sir Isaac	1				
Molecular Theory	2				
Expansion of a solid due to heat		3			
Transference of Heat--Convection		2			
Transference of Heat--Radiation		2			
Expansion of liquids due to heat		3			
Change of State Solid to Liquid		1			
Measurement of Heat--Calories		3			
Change of State--Liquid to Gas		1			
Boiling temperature		3			
Mechanical Equivalent of Heat		1			
Heat Energy		5			
Sound Waves			4		
Heat of Vaporization		1			
Frequency of a Sound Wave			2		
Human Ear			1		
Characteristics of Musicians' tones (general)			2		
Speed of Sound in air			3		
Beats			1		
Laws of Strings			2		
Laws of Pipes			1		
Ability to see an object				2	
Lenses--Convex				6	
Speed of Light				3	
Intensity of Illumination--Candle-power				2	
Reflection of Light				3	
Illumination--Foot Candles				1	
Spherical Mirrors				2	
Index of Refraction				2	
Refraction				6	
Total reflection				3	
Camera				3	
Compound Microscope				1	
Dispersion of Light by a prism				2	

Topic	Mechanics	Heat	Sound	Light	Electricity
Equilibrium	2				
Freely falling bodies	2				
Energy--Potential & Kinetic	6				
Energy--Kinetic	2				
Energy--Potential					
Power rate of work of machines	2				
Mechanical Adv. of a machine	2				
Horsepower	2				
Efficiency of a machine	3				
Friction	1				
Moment of force	12				
Forces	2				
Forces at a Fulcrum	4				
Principle of Moments	1				
Centripetal force	2				
Barometer (in general)	1				
Change from C scale to F. scale		2			
Transference of Heat--Insulation		1			
Newton. Air Issac	1				
Molecular Theory	2				
Expansion of a solid due to heat		3			
Transference of heat--Convection		2			
Transference of heat--Radiation		2			
Expansion of liquids due to heat		3			
Change of state Solid to Liquid		1			
Measurement of heat--Calories		3			
Change of state--Liquid to Gas		1			
Boiling temperature		3			
Mechanical Equivalent of Heat	1				
Heat Energy	3				
Sound Waves			4		
Heat of Vaporization		1			
Frequency of a Sound Wave			2		
Human Ear			1		
Characteristics of Positive' Ions (General)			3		
Speed of sound in air			2		
Echos			1		
Laws of strings			3		
Laws of Pipes			1		
Ability to see an object					
Lenses--Convex					
Speed of light					
Intensity of Illumination--Candle-power					2
Reflection of light					1
Illumination--Foot Candles					1
Spherical Mirrors					2
Index of Refraction					2
Refraction					2
Total reflection					1
Camera					1
Compound microscope					1
Dispersion of light by a prism					2

Columbia Research Bureau
Physics Test

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Magnetism by Induction					1
Magnetic Compass					1
Permanent Magnets					1
Angle of Magnetic Declination					1
Polarization					1
Electroscope--Charging by Induction					3
Condensors					1
Electric Cells--General					2
Electric Cells--Voltaic					5
Storage Cells					8
Magnetic field about a Conductor					3
Laws of Resistance					3
Measurement of Electric Current					1
Electrical Power--K. W. H's.					2
Electromagnets					4
Telegraphic Relay					1
Electrical Energy--Watts					2
Ohms Law					3
Ammeter					1
D. C. Motor					1
Generators					2
Heating Effect of a Current--I^2R					3
Voltmeter					1
Induced Currents					6
Newtons Laws of Motion	2				
Electron Theory					4
Oscillating Circuits					1
Deflection of Electrons					1
Gravity--Weight of a body	2				
Curvilinear Motion Centripetal force	1				
Thermometry--degree of Heat		1			
Transference of Heat--Conduction		1			
Specific Heat		2			
Freezing point of water		2			
Charles Law-Ex. of gases due to heat		1			
Echo			1		
Resonance			1		
Diffusion of Light			1		
Astronomical Telescope			1		
Magnetic forces					1
Static Electricity					1
Electrolysis of water					
Connection in Series					2
Polarization of cells					1
Connection in Parallel					2
Lamps					2
Properties of Matter	1				
Chromatic Aberration				1	
Polarization of light				1	
Wheatstone Bridge					1

Columbia Research
Bureau Physics Test

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Metric System	1				
Pascal's Law	1				
Volume of a block	1				
Co-efficient of Linear Expansion		1			
Origin of Sound			1		
Sound Waves			1		
Thermometry--Absolute Scale		2			
Heat of fusion		1			
Reflected Light-Angle of Incidence				2	
Concave Mirrors				1	
Polarization of Cells					2
Conductors of Electrcity					2
Lamps connected in Parallel					1
Transfer of Eng. to Met., Met. to Eng.	1				
Mechanical Advantage	1				
Center of Gravity	1				
Thermometry--Degree of Heat		1			
Measurement of Heat Calories		1			
Refraction				1	
Properties of a Magnet					1
Connection in Series					1
Electric Energy--K W H					1
Power--Rate of doing work	1				
Watt-hour meter					1

Name of Test: Black-Burlingame Test in Elementary Physics
Author: N. Henry Black
Francis M. Burlingame
Publisher: Ginn & Company
Date of Publication: 1927

This test in elementary physics was produced by N. Henry Black and Francis M. Burlingame of Harvard University and is known as one of the Harvard Tests. The purpose of the test according to the authors is "to measure the achievement of students who have completed a year's work in elementary physics."

The percentage of thought and fact items seem to be fairly well distributed in this test but the distribution of questions under the various divisions does not correspond very closely to the distribution of the eleven text books taken as a mean. The authors claim that they have analyzed three sources to get their list of questions. With this elimination of questions not common to the eight texts, they seem to have eliminated so many topics that the sections are not adequately covered, and the test is not so long as it should be to increase the reliability.

The material for the test was chosen after an analysis of the subjects generally included in a high school course in physics. The topics were taken from (1) the definition of the requirements in physics of the College Entrance Examination Board, (2) Syllabus in Physics for Secondary Schools by the regents of the University of the State of New York, (3) Eight commonly used text books which are as follows: Black and Davis, "Practical Physics"; Carhart and Chute, "Practical Physics"; Dull, "Essentials of Modern Physics"; Gorton, "A High Schools Course in Physics"; Hoardley, "Essentials of Physics"; Millikan and Hale, "Practical Physics"; Sears, "Physics for

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Secondary Schools "; Tower, Smith, Turton, and Cope, "Physics." The topics taken from the above were listed on cards. Those that appeared in less than nine of these sources were discarded and a detailed analysis of those remaining was made to determine the type of knowledge essential for mastery of these topics. The questions were then divided into five tests, containing 320 items. Following the submission to the members of the Department of Physics and the Graduate School of Education in Harvard University for criticism, each test was given to several hundred students. On the basis of these papers a number of the questions were eliminated and the remainder were then arranged in pairs of equivalent difficulty with the resulting forms A and B of sixty items each.

Both forms of the test were given to 1741 students on successive or approximately successive days. The reliability coefficient based on correlating the two forms of the test was .801 with a probable error of ± .005.

The norms, based on 2026 cases, well scattered over the country, are listed as follows for both form A and form B.

Form	First Quartile	Median	Third Quartile	Sigma
A	27.3	33.3	39.6	8.4
B	27.6	33.6	40.0	8.6

This means that in Form A, for instance, the median student made a hypothetical score of 33.3 and the lowest quarter fell below 27.3 and the highest quarter above 39.6. Sixty-eight per cent of the students made scores between (33.3-8.4) or 24.9 and (33.3+8.4) or 41.7

Each test is divided into three parts. The first consists of true-false questions, 26 in form A and 24 in form B. The Second consists of completion questions, 11 in form A and 10 in form B.

The third part consists of multiple response questions, 23 in form A and 26 in form B.

The administration of the test is easy, the directions being given on each one of the examination papers at the beginning of each section. Adequate illustrations are given. The test is to be finished in exactly thirty-five minutes. A key for correction is furnished with each set of examinations. The scoring of the true-false is simply the number right, which score the authors attempt to prove is as fully reliable as the right minus wrong method. The time taken in scoring is somewhat lengthened in all the cases by certain mechanics that might easily have been corrected. The true-false consists of two columns of the words true and false. The pupil is to underline the correct response. This either necessitates going over each list separately or going more slowly over both lists. In both the completion and multiple-response the answers are staggered, which fault might have been overcome by numbering the various choices and requiring the correct number to be placed in a space provided at the right of the page. If these tests are used, we might use a transparent stencil as suggested by Ruch,[1] but even this, according to the writer's experience, is somewhat tedious.

The tests come in packages of 30 each with a scoring key and list at $1.00 per package subject to a discount of 25 per cent, or 75 cents net, plus transportation charges.

1. Ruch, G. M. The New Type or Objective Test p.p. 180-182

TABLE NO. 21

Thought and Fact Items in Black and Burlingame Physics Tests

	Form A	Form B
Total number of items	60	60
Number of thought items	48	50
Percentage of thought items	80%	83.33
Number of fact items	12	10
Percentage of fact items	20%	16.67

TABLE NO. 22

Comparison of Percentage Composition of Black and Burlingame's Physics Test with the Mean as to Percentage Composition of Eleven Text Books.

	Percentage of books	composition of tests Form A	Form B
Mechanics	33.64	46.67	41.67
Heat	14.53	10.00	15.00
Sound	7.14	5.00	5.00
Electricity	31.10	23.33	25.00
Light	13.38	15.00	33.33

TABLE NO. 23

The Distribution of Thought and Fact Items According to Subject Matter in Black and Burlingame Physics Tests.

Form A Thought Items	Mechanics	Heat	Sound	Light	Electricity
Boiling Point		1			
Magnetic Field					1
Kinetic Energy	2				
Efficiency of Machine	2				
Transference of Light				2	
Specific Gravity	1				
Atmospheric Pressure	1				
Molecular Theory	1				
Steam Engine	1	1			
Wave Length Sound			1		
Fuses					1
Intensity of Light				1	
Freely Falling Bodies	2				
Generators					1

Black and Burlingame

Form A

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Displacement--floating bodies	2				
Principle of Moments	2				
Tensile Strength	1				
Illumination--Candle Power				1	
Deciding a charge by an electroscope					1
Laws of Resistance					1
Image of Lens				1	
Mech. Equivalent of Heat		1			
Motor					1
Center of Gravity	1				
Voltaic Cell					1
Speed of Light				1	
Inclined Plane	2				
Sideways Pressure	2				
Gas Engine		1			
Magnetic Effect of an Elec. Current					1
Boyles Law	1				
Newtons First Law--Inertia	1				
Force of Gravity	1				
Coefficient of linear Expansion		1			
Heating Effect of Current					1
Transformer					1
Fact Items					
Light Waves				1	
Spectra-Bright Line				1	
Conductors of Electricity					1
Spectrum--Solar				1	
Electron Theory					2
Pitch of a Musical Note			1		
Storage Cell					1
Fundamental			1		
Metric to English	1				
Power	1				
Atmospheric Pressure	1				

Form B

Fact Items					
Transformers					1
Pitch of Musical Sound			1		
Absolute Zero		1			
Condensor--Leyden Jar					1
Horsepower	1				
Mech. Equivalent of Heat		1			
Gravity	1				
Pascals Law	1				
Ohm's Law					1
Intensity of Illumination --Foot Candles				1	

Black and Burlingame
Form B

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Capillary Action	1				
Specific Gravity--Floating body	1				
Specific Gravity--Liquids	1				
Density	1				
Efficiency of Machines	1				
Pullies	1				
Fluid Pressure	2				
Gravity	1				
Specific Heat		1			
Resistance					1
Magnetic Effect of an Electric Current					1
Cooling due to Melting		1			
Electron Theory					1
Transmission of light--Colors				1	
Potential Energy	1				
Colors				1	
Friction	1				
Conductors of Electricity					1
Transference of Sound			1		
Thermometer, Centigrade		1			
Force Pump	1				
Boyles Law	2				
Barometer	2				
Displacement--Submerged bodies	2				
Heat Engines--Carburator		1			
Resultant of Forces	1				
Electric Cells					2
Siphon	1				
Boiling Point of Water		1			
Images found by a Convex Lens				1	
Transference of Heat--Convection		1			
Lens--Convex				1	
Hookes Law	1				
Component Forces	1				
X-Rays					1
Defects of the Eyes				1	
Storage Cell					1
Induced Currents					2
Intensity of Sound			1		
Doppler's Principles				1	
Index of Refraction				1	
Heating Effect of a Current					1
Watts					1
Expansion due to Heat		1			

Name of Test: Michigan Instructional Tests in Physics
Author: Paul V. Sangren
Walter G. Marburger
Publishers: Public School Publishing Company
Date of Publication: 1929

These tests are compiled in three parts, (1) An initial test, to determine the fitness of the student to take physics and to show up the particular strength and weaknesses of the individual pupil, (2) A series of twenty-two instructional tests, to check pupils' achievements during the course of instruction, (3) A final examination to be applied at the end of the work composed of random samples from the instructional tests.

The initial test is so constructed as to determine what general information the student has on the subject of physics. It consists of three parts (1) General information connected with physics, (2) Mathematical problems of the type that are involved in physics, (3) Information on scientific reading.

Five commonly used text books were used as a basis for determining the questions in the instructional tests. These texts were (1) Carhart and Chute-"Practical Physics", (2) Black and Davis-"New Practical Physics", (3) Milliken and Gale-"Elements of Physics", (4) Dull -Mordern "Physics", (5) Fuller, Brownlee, and Baker-"Elementary Principles of Physics". The great majority of the questions appear in all the texts. The remainder of the questions appear in a majority of the books while the answer to the questions may be inferred from the material in the other texts.

The final examination is composed of random samples from each of the twenty-two tests, and is composed of 120 questions. The items are a mixture of completion and multiple choice types. The distribution of thought and fact items is very good for this type of examination. The percentage composition, while not corresponding

exactly to the percentage distribution of eleven text books, is fairly close and hence this would be a good examination to give for a final test of achievement in high school physics.

The phases covered by the various instructional tests together with other information may be seen in the following table which is a composite of three tables taken from the manual.

TABLE NO. 24

Phases Covered by Various Instructional Tests in Michigan Instructional Tests in Physics

Test No.	Section Covered	No. of Items	Reliability Coeff.	Median	No. of Cases for Med.
	Information	30		21.6	203
	Mathematics	23		16.9	203
	Scientific Reading	20		18.2	203
	Total (Initial Test)	73	.88	56.	203
1	Metric & English Units	40	.83	26.	790
2	Density, Specific Gravity, & Mechanics of Liquids	38	.69	27	791
3	Mechanics of Gases	31	.79	23	847
4	Vectors, Forces, and Gravitation	27	.46	18	721
5	Motion	32	.74	23	773
6	Molecules & Molecular Forces	26	.45	21	706
7	Work, Energy, Power & Simple Machines	39	.77	27	771
8	Thermometry & Expansion	30	.86	21	880
9	The Nature & Measurement of Heat	27	.82	20	730
10	Change of State	30	.80	21	702
11	Transmission of Heat	27	.72	23	759
12	Magnetic Phenomena	30	.77	24	893
13	Static Electricity, Potential, Capacity	39	.80	30	796
14	Magnetic Effect of a Current	23	.48	17	818
15	Chemical Effects of an				
16	Electric Current	37	.82	28	749
16	Electric Currents and Measurement	29	.72	21	750
17	Induced Currents	26	.91	19	750
18	Nature & Transmission of Sound	27	.74	22	729
19	Vibrating Strings & Air Columns	20	.84	13	705
20	Nature & Transmission of Light	25	.64	21	694
21	Images in Mirrors & Lenses	26	.88	18	592
22	Color & Spectra	22	.80	18	549

Test No.	Section Covered	No. of Items	Reliability Coeff.	Median	No. of Cases for Med.
Final Test	Mechanics	43		31	735
	Heat	21		16.5	735
	Magnetism & Electricity	33		24.6	735
	Sound	9		7.5	735
	Light	14		10.7	735
	Total (Final Exam)	120	.94	90.5	735

The validity is obtained by intercorrelating the scores on the various instructional tests. These are found to run from .13 to .75, the great majority of the coefficients correlate about .50. This may considered a fair correlation, indicating that the tests are valid measures of students' ability in high school physics, but that each of the separate tests do not measure the same ability. The coefficients of correlation between final semester marks in physics and score on separate tests of the series average .50 but run as high as .65. This, also, may be considered a relatively high coefficient when all the variable factors are taken into consideration.

The reliability of the various tests is obtained by correlation of chance halves of the examinations and correction secured through the use of Brown's formula. These coefficients may be found by consulting the table. The average of the twenty-two coefficients is .80.

The administration of these tests is not difficult. In the initial and final examinations the instructions are given on the paper itself, while the directions for the instructional tests are always the same and are given in the manual of directions. Each pupil owns one of the instructional test books which is kept by the teacher. When the tests are taken, they may be torn out of the book so that the pupil may keep a record of just where he stands. The pupil is instructed to draw a circle around each of his scores and

draw a line connecting each of the circles. These charts also give the range of scores compiled by the authors' ranks of A, B, C, D, and E. When the pupil circles his score, he automatically gives himself a letter grade. There is a question as to whether this is an advantage or not due to differences in conditions and differences of marking systems. The questions are either multiple-response or completion, problems being of the completion type with space left for calculations. The teacher is provided with a record sheet upon which the marks are recorded. The time required to take the test is not given,but the authors say that they should not take over 45 minutes.

The norms are given in the form of a median which may be found by consulting the table, together with number of cases used in determining it. The teacher is requested to send in the record of her class so that further norms might be made.

In translating their scores into letter grades, which are used on the profile chart, the authors used the following procedure. They made the assumption that in so many cases the scores would take a normal distribution. They took the following rather commonly used division, A-5 percent, B-20 percent, C-50 percent, D-20 percent and E-5 Percent. They applied this to their total number or marks and obtained the results given on the profile chart.

The tests come in convenient packages on good paper. The cost is: Initial Test: Price 50c per package of twenty-five tests, one class record sheet (with answers), and one Manual of Instructions. Sample set, 10c.

Instructional Tests: Price, 30c for the complete book of twenty-two Instructional Tests. One class record sheet, one Manual of Instructions, and one answer sheet free with every twenty-five books ordered. Extra class record sheets, 2c each. Extra Manuals of

Instructions, 5c each. Extra answer sheets, 5c each.

Final Examination: Price $1.00 per package of twenty-five tests, one class record sheet (with answers), and one Manual of Instructions. Sample set, 10c.

Complete sample package: Price 60c. This includes initial test, complete book of twenty-two Instructional Tests, and Final Examination, with all accessory material.

TABLE NO. 25

Thought and Fact Items in Michigan Instructional Physics Tests

Final examination

Total number of items	120
Number of thought items	81
Percentage of thought items	67.5
Number of fact items	39
Percentage of fact items	32.5

TABLE NO. 26

Comparison of Percentage Composition of Michigan Instructional Test With the Mean as to Percentage Composition of Eleven Text Books.

	percentage of books	composition of testss
Mechanics	33.64	35.83
Heat	14.53	17.5
Sound	7.14	7.5
Electricity	31.10	27.5
Light	13.38	11.67

TABLE NO. 27

The Distribution of Thought and Fact Items According to Subject Matter in Michigan Instructional Physics Test.

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Action of Water above and below 4° C		1			
Coefficient of Expansion		1			
Relative Humidity		1			
Freezing point of water		1			
Condensation of Steam Heat given off		1			
Specific Heat		1			
Storage Battery					3
Cells attached in Series					1
Quantity of Electricity--Coulombs					1
Electromagnet					1
D. C. Motor--Starting					1
Anode--Cathode					1
Electrical Conductors					1
Magnetic Compass					1
Determination of Charge by an Electroscope					1
Perm. Magnets--How made					1
Magnet as compass					1
Static Electricity					1
Electron Theory					1
Voltaic Cell					1
Electroplating					1
Volt					1
Charging a condensor					2
Magnetic Effect of current					3
Polarization of a Cell					1
Induced Current					2
Ammeter					1
Ohm's Law--E=IR					1
Generators					1
Connections in Series					1
Transfer of Sound through a vacuum			1		
Hookes Law	1				
Specific Gravity	1				
Specific Gravity--Liquids	1				
Resultant of forces	1				
Boyles Law	1				
Fluid Force	1				
Potential Energy	1				
Pendulum	1				
Freely falling bodies	1				
Capillary Action	2				
Wheel and Axle	1				
Sideways pressure	1				
Metric System	1				
Moment of Force	1				
Displacement--Floating bodies	1				
English to Metric	1				
Mass of a body	1				

Michigan Instructional Physics Test Thought Items	Mechanics	Heat	Sound	Light	Electricity
Syphon	1				
Weight	1				
Pendulum	1				
Expansion due to heat		1			
Motion--Accelerated	1				
Kinetic--Energy	1				
Fluid Pressure	1				
Calories		2			
Heat of Vaporization		1			
Transference of Heat--Convection		2			
Absorption of Heat		1			
Thermometers		2			
Heat of fusion		1			
Charles Law		1			
Transfer of sound through a solid			1		
Beats			1		
Overtones			1		
Law of Strings			1		
Images in a Lens				1	
Spectra				1	
Refraction of light				1	
Index of refraction				1	
Images in a curved mirror				1	
Fact Items					
Metric to English	3				
Pascals Vases	1				
Acceleration of Gravity	1				
Atmospheric Pressure	1				
Motion--Acceleration	1				
Density	1				
Boyles Law	1				
Elastic Limit	1				
Center of Gravity	1				
Power	1				
Metric System	1				
Energy	1				
Mass of a body	1				
Work	1				
Acceleration of Gravity	1				
Calories		1			
Transference of Heat--Convection		1			
Dew Point		1			
Relative Humidity		1			
Absolute Scale		1			
Natural Magnet					1
Daniell Cell					1
Magnetic Dip					1
Fundamental			1		
Dopplers' Principle			1		
Sound Waves			1		
Major Chords			1		
Refraction				1	

Thought Items	Mechanics	Heat	Sound	Light	Electric
Bryden	1				
Bridge	1				
Pendulum	1				
Expansion due to heat		1			
Bridge--accelerated	1				
Kinetic--Energy	1				
Fluid pressure	1				
Calories		1			
Heat of Vaporization		1			
Transference of Heat--Convection		1			
Absorption of Heat		1			
Thermometers		1			
Heat of Fusion		1			
Charles Law		1			
Transfer of sound through a solid			1		
Media			1		
Overtones			1		
Law of Strings			1		
Images in a lens				1	
Degree				1	
Reflection of light				1	
Index of refraction				1	
Images in a curved mirror				1	

Heat Items

Metric to English	8				
Periodic Waves	1				
Acceleration of Gravity	1				
Atmospheric Pressure	1				
Motion--Acceleration	1				
Density	1				
Boyles Law	1				
Plastic Limit	1				
Center of Gravity	1				
Power	1				
Metric System	1				
Energy	1				
Mass of a body	1				
Work	1				
Acceleration of Gravity	1				
Calories		1			
Transference of Heat--Convection		1			
Dew Point		1			
Relative Humidity		1			
Absolute Scale		1			
Natural Degree					1
Dewell Cell					1
Magnetic Dip					1
Fundamental			1		
Dopplers' Principle			1		
Sound Waves			1		
Major Chords			1		
Refraction				1	

Michigan Instructional Physics Test Fact Items	Mechanics	Heat	Sound	Light	Electricity
Image in a plane mirror				1	
Non-luminous bodies				1	
Dispersion of light through a prism				1	
Frauenhofer Lines				1	
Wave length of Colored light				1	
Speed of light				1	
Images in curved mirror				1	

Name of Test: Hurst Tests in High School Physics
Author: M. E. Hurst
Publisher: Harlow Publishing Co.
Date of Publication: 1930

These tests were constructed by M. E. Hurst of the Central High School, Tulsa, Oklahoma, under the direction of G. C. Wells, Secretary of the Board of Education of Oklahoma. There are eight different tests as follows; (1) Measurement of Mechanics and Fluids (2) Mechanics of Solids, (3) Heat, (4) Magnetism, Static and Current Electricity (5) Induced Currents and Sound (6) Light and Invisible Radiations (7) A first Semester Test, (8) and Second Semester Test.

The items are the true-false, completion, and multiple-response type, with varying amounts of each in each test. The final examinations are sample questions taken from the first six tests. One form covers the first three, and the other covers the last three topics.

In constructing this test the manual says that instead of random sampling they have included essential elements of each unit. The writer in going over the tests came upon a number of duplicate questions. For example a question is asked in the part of the examination covered by completion questions on the floating of a needle due to surface tension while there is a question covering the same information in the part covered by multiple choice questions. The elements were determined by analyzing courses of study and text books in the field of physics, supplemented by opinions of teachers of the subject, and finally were decided upon by the author. The manual does not state what text books were studies nor does it give any other information upon validity other than that given above. The claim for a well balanced test seems to be well founded. The number of thought and fact items is divided about equally among the total number of questions and the percentage composition compares very favorably with the percentage composition of the eleven text books.

There is however no reliability coefficient given, the only mention of reliability being the following. "The Comprehensive Objective Tests in High School Physics, then possess the factors that make for a high degree of validity and reliability." This test then satisfies the major criteria but must be looked upon with doubt becuase of not satisfying the minor criteria.

The administration of the test is comparatively easy. Forty minutes is the time allowed, and, consequently, they can be taken in the time usually allowed for a period. The manual suggests that in addition to the samples given in the test at the beginning of each section, the teacher should also put additional samples on the board so that all the pupils may understand what they are to do. The directions as to what the pupils are to do are also given at the beginning of each section on the examination paper.

Scoring is facilitated by having all of the responses in a column and the tests can be corrected by placing the key, which is furnished, beside the column and checking those answers that are incorrect. The score on the true-false section is the number right minus the number wrong, the scores on the multiple-choice and the completion are found by counting the number of correct responses. Class record sheets are provided and also instructions as to how to find the median.

There are no norms furnished with the tests but teachers are urged to send in the scores on the tests in order that a set of norms may be established. Blanks for this purpose accompany the test.

The prices of the tests are as follows: single copies, 10 cents each; single copies of keys, 10 cents each; packages containing 25 tests of the same title, one key and one manual of directions, 75 cents; packages containing 100 tests of the same title, two keys and one

manual of directions, $2.50; broken packages of less than twenty-five and more than 14 copies of the same test, 75 cents, with one free key; broken packages of less than 15 and more than 5 copies of the same test, 5 cents a test and 5 cents for the key. Prices are net, F. O. B. Oklahoma City.

TABLE NO. 28

Thought and Fact Items in Hurst's Final Tests in High School Physics.

Total number of questions	207
Number of thought items	102
Percentage of thought items	49.28
Number of fact items	105
Percentage of fact items	50.72

TABLE NO. 29

Comparison of Percentage Compositions of Hurst's Final Test in High School Physics with the Mean Percentage Composition of Eleven Text Books.

	Percentage composition of books	Hurst tests.
Mechanics	33.64	39.61
Heat	14.53	14.01
Sound	7.14	5.80
Electricity	31.10	25.12
Light	13.38	15.46

TABLE NO. 30

The Distribution of Thought and Fact Items According to Subject Matter in Hurst Semester Tests in High School Physics.

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Hydrometer	2				
Vacuum	2				
Weight of air	1				
Compressability of Water	1				
Barometer	1				
Siphon	1				
Lift Pump	2				
Boyles Law	1				
Velocity of falling bodies	1				
Newton's Laws of Motion	2				
Efficiency of a machine	2				
Expansion and Contraction due to heat and cold		2			
Temperature on absolute Scale		1			
Heat of Vaporization		1			
Heat of fusion		1			
British Thermal Units		1			

Hurst Semester Tests
in High School Physics

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Resultant of Forces	1				
Definition of Physics	1				
English to Metric or vice versa	3				
Definition of Atmosphere	1				
Kinetic theory of Gases	1				
Diffusion	1				
Stability of a body	1				
Machine--Definition	1				
Transfer of Heat--Radiation		1			
Melting point		1			
Metric System	1				
Fluid Pressure	1				
Acceleration of Gravity	1				
Inertia	1				
Freely falling bodies	1				
Acceleration	1				
Newtons Law of Gravitation	1				
Calories--definition		1			
Mechanical equivalent of Heat		1			
Weather maps--Isobars		1			
Relative Humidity		1			
Law of Attraction and repulsion					1
Electricity by friction					1
Positive and negative Electricity					1
Volt definition					1
Dry Cell					1
Connection in series					1
Ohm--Definition					1
Storage batteries					2
Induced Currents					3
Induction coil					2
Transformer					1
Telephone					3
Generators					1
Law of Strings			2		
Pitch of a tone			2		
Convex lens				1	
Dispersion of light				1	
Wave theory of light				1	
Image in a Concave mirror				2	
Human Eye				1	
Radio activity					1
Theory of Magnetism					1
Magnetic Induction					2
Demagnetizing a magnet					1
Condensor					1
Ohm's Law					1
Motor--definition					1
Watts--definition					1
Commutator					1
Velocity of Sound in air			1		
Echoes			1		
V = N L			1		
Transverse waves				1	

Hurst Semester Tests
in High School Physics

Fact Items	Mechanics	Heat	Sound	Light	Electricit
Resultant of Forces	1				
Definition of Physics	1				
English to Metric or vice versa	3				
Definition of Atmosphere	1				
Kinetic theory of Gases	1				
Diffusion	1				
Stability of a body	1				
Machine--Definition	1				
Transfer of Heat--Radiation		1			
Melting point		1			
Metric System	1				
Fluid Pressure	1				
Acceleration of Gravity	1				
Inertia	1				
Freely falling bodies	1				
Acceleration	1				
Newton's Law of Gravitation	1				
Calories--definition		1			
Mechanical equivalent of Heat		1			
Weather maps--Isobars		1			
Relative Humidity		1			
Law of Attraction and repulsion					1
Electricity by friction					1
Positive and negative Electricity					1
Volt definition					1
Dry Cell					1
Connection in series					1
Ohm--Definition					1
Storage batteries					2
Induced Currents					3
Induction coil					2
Transformer					1
Telephone					3
Generators					1
Law of Strings			2		
Pitch of a tone			2		
Convex lens				1	
Dispersion of light				1	
Wave theory of light				1	
Image in a Concave mirror				3	
Human Eye				1	
Radio activity					1
Theory of Magnetism					1
Magnetic Induction					2
Demagnetizing a magnet					1
Condensor					1
Ohm's Law					1
Motor--definition					1
Watts--definition					1
Commutator					1
Velocity of Sound in air			1		
Echoes			1		
V = R I			1		
Transverse waves				1	

Hurst Semester Tests
in High School Physics

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Shadows				1	
Permanent Magnets				1	1
Electroscope					1
Insulators					1
Electric bell					1
Simple Cell					1
Index of Refraction				1	
Velocity of light				2	
Opaque bodies				1	
Spectrascope				1	
Periscope				1	
Thought Items					
Metric to English System	1				
Specific Gravity	1				
Floating bodies	2				
Displacement of submerged bodies	1				
Air pressure	1				
Molecular Theory	1				
Laws of the Pendulum	1				
Resultant of Forces	2				
Weight of an object--gravity	1				
Center of gravity	1				
Kinetic Energy	1				
Mechanical Advt. of a machine	1				
Horsepower	2				
Transfer of Heat--Convection		2			
Condensation		1			
Amount of heat--calories		1			
Vaporization		1			
Steam Engine		2			
Mass	1				
Use of Barometer	2				
Atmospheric Pressure	2				
Freely falling bodies	2				
Friction	1				
Expansion and Contraction due to heat and cold	1				
Boiling point of liquids	2				
Transfer of energy	2				
Density	1				
Fluid pressure	1				
Surface Tension	2				
Work	1				
Levers	1				
Power and Work	1				
Heat of fusion		2			
British Thermal Units		1			
Bunsen Burner--gas flame		1			
Universal properties of matter	3				
Specific properties of Matter --Ductility	1				

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Abacus					1
Permanent Magnets					1
Microscope					1
Projectors					1
Electric bell					1
Electric bell					1
Index of Refraction	1				
Velocity of light	1				
Opaque bodies	1				
Spectroscope	1				
Telescope	1				

Thought Items					
Metric to English System	1				
Specific Gravity	1				
Floating bodies	1				
Displacement of submerged bodies					
Air pressure	1				
Molecular Theory	1				
Laws of the Pendulum	1				
Resultant of forces	1				
Weight of an object--gravity	1				
Center of gravity	1				
Kinetic Energy	1				
Mechanical Adv. of a machine	1				
Horsepower	1				
Transfer of heat--Convection		1			
Condensation		1			
Amount of heat--calories		1			
Vaporization		1			
Steam Engine		1			
Heat		1			
Use of Barometer		1			
Atmospheric Pressure		1			
Freely Falling Bodies		1			
Friction		1			
Expansion and Contraction due to heat and cold		1			
Boiling point of liquids		1			
Transfer of energy		1			
Density		1			
Fluid pressure		1			
Surface Tension		1			
Work		1			
Levers		1			
Power and Work		1			
Heat of fusion			1		
British Thermal Units			1		
Bunsen Burner--gas flame			1		
Universal properties of matter	1				
Specific properties of matter					
--Quantity	1				

Hurst Semester Tests
in High School Physics

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Capillarity	1				
Pullies	1				
Hooke's Law	1				
Inclined Plane	2				
Efficiency of a machine	2				
Evaporation		1			
Coefficient of linear Expansion		1			
Melting Point		1			
Vacuum Bottle		1			
Boyles Law	1				
Specific Heat		1			
North Magnetic Pole					2
Electroscope					2
Resistance of a wire to a current					2
Electro-plating					1
Watts					3
Speed of sound in air			2		
Transmission of sound			2		
Intensity of Illumination				3	
Index of Refraction				2	
Speed of light				1	
Illuminated Bodies				1	
Shadows				2	
Efficiency of a light				1	
Color				2	
Rainbow				1	
Absorption of Heat		1			
Luminous bodies				1	
Vacuum tubes					1
Connection in parallel					1
Watts-Hours					1
Induction coil					1
Transformer					1
Image in a plane mirror				1	
Angle of Declination					1
Storage battery					1
Magnetic effect of a current					1
Heating effect of a current					1
Wave length, velocity, frequency				1	
Correct lighting				1	
Refraction of light				1	

Name of Test: Hurd's Final Test in High School Physics
Author: A. W. Hurd
Publisher: Bureau of Publications, Teachers College Columbia University
Date of Publication; 1930

This test was constructed by A. W. Hurd of the Institute of School Experimentation, Teachers College, Columbia University. The test is published in three forms A, B, and C, form A having 95 items, form B 93 items and form C 95 items. The three types of questions used are the simple recall, multiple choice and completion.

These tests have a very good scattering of thought and fact items, but the distribution of questions under each topic does not correspond to the percentage composition of eleven text books. There is some doubt as to whether this test could be used as a final examination because there is too much stress placed on mechanics in each of the three forms of theexamination.

According to the manual validity is based on (a) selection of common concepts from current text books, (b) increases in scores due to instruction, (c) substantial correlation with teachers' grades, (d) elimination of all items not differentiating between the lowest and highest thirds of students taking the test, (e) common use and refinement of items in classroom teaching for a period of six years, (f) correlations with other standardized tests in physics. This highest correlation between this test and teachers' marks is .86±.03 in classes where the test scores did not contribute to the marks.

The reliability by the split halves method is .91±.01 for each form; between forms A and B, .91±.02; and between B and C, .87±.03. Probable errors of test scores are: form A, 3.68; form B, 3.96; form C, 3.84.

The directions for taking the examinations are given at the beginning of each section of the examination. There are no illustrations given and there is a possibility of the pupil becoming

confused in the multiple response part. The directions are that the pupil shall choose the correct answer in each of the following items and designate by number in the parenthesis at the right; for example (3). Then follow several items of this type. With no additional directions, the type changes to the type of which the following is an illustration. "From the following designate by number those physical characteristics possessed by pure air: (1) color (2) weight (3) compressibility (4) expansibility (5) a definite volume when unconfined (6) density (7) a definite shape (8) specific gravity (9) taste, where five answers; 2, 3, 4, 6, and 8 are expected. This type is scored differently than the others. The directions are that there is to be one credit per number. Subtract one for each incorrect answer down to o. The other questions are scored one for each correct response. A key is provided for scoring. Some variations are allowed in certain answers. If the meaning of the word given is synonymous, credit is given and a variation of 1% in numerical answers is allowable.

Norms are given as percentile scores by tens, and as means and standard deviations or sigma scores. They are also given as "M" scores which means that position is shown in distribution of abilities that is assumed to be normal. This gives a basis for grading, according to the author.

The cost of the tests is $2.00 per 100 for one or more forms with which a manual of directions and a key is provided. A sample set containing one copy of each form and manual may be had for 10 cents.

TABLE NO.31

Thought and Fact Items in Hurd's Final Test in High School Physics

	Form A	Form B	Form C
Total Number of questions	95	93	95
Number of thought items	67	60	62
Percentage of thought items	70.53	64.52	65.26
Number of fact items	28	33	33
Percentage of fact items	29.47	35.48	34.74

TABLE NO.32

Comparison of Percentage Composition of Hurd's Final Test in High School Physics with the Mean as to Percentage Composition of Eleven Text Books

	Percentage composition of books	Form A	Form B	Form C
Mechanics	33.64	53.68	52.69	47.37
Heat	14.53	21.05	2o.43	20.00
Sound	7.14	3.16	6.45	7.37
Electricity	31.10	11.58	10.75	12.62
Light	13.38	10.53	9.68	12.62

TABLE NO.33

The Distribution of Thought and Fact Items According to Subject Matter in Hurd's Final Test in High School

Form A	Physics				
Fact Items	Mechanics	Heat	Sound	Light	Electricity
Metric System	3				
Metric to English, or Vs.	1				
Velocity of light				1	
Freezing point of water		1			
Unit for measuring heat		2			
Dew point		1			
Unit of Electric Resis.-Ohms					1
Static Electricity					1
Electron Theory					1
Rectifiers					1
Mechanical Advantages	1				
Specific Gravity-Gen.	1				
Hydrometer	1				
Pascals Law	1				
Hookes Law-Elasticity	1				
Acceleration	1				
Centrifugal Force	1				
Musical Scales			1		
Lenses				1	

Hurd's Test
Physics Test

Fact Items	Mechanics	Heat	Sound	Light	Electricity
Source of Heat Energy		1			
Distillation of Water		1			
Heat of Vaporization		1			
Thermograph		1			
Heat of Fusion		1			
Thought Items					
Metric to English	1				
Metric System	3				
Specific Gravity-Floating Body	1				
Fluid Pressure	1				
Specific Gravity-Liquids	1				
Displacement-Submerged Bodies	1				
Sideways Pressure	1				
Atmospheric Pressure	7				
Displacement fluids-Floating bodies	1				
Exhaust Pump	1				
Forces	1				
Resultant Forces	1				
Work in Ft. lbs.	2				
Freely falling bodies	1				
Reflection of light-color				1	
Spectrum-bright line				1	
Convex lens image				6	
Action of water due to heat and cold		1			
Law of Magnets					1
Determination of Elect. Charge by means of an Electroscope					1
Theory of Magnetism					1
Watts and Candle power					1
Resistance on Series					1
Ohm's Law					1
Efficiency of Transformers					1
Principle of Moments	1				
Wheel and Axle	1				
Levers	2				
Pullies	1				
Physical Properties	5				
Characteristics of a Musical Sound			2		
Index of Refraction				1	
Water Meter	1				
Component Forces	1				
Measurement of Energy	1				
Acceleration	1				
Transmission of Sound	1		1		
Laws of the Strings-Length			1		
Wave length from a closed pipe			-		
			1		

Hurd's Test Thought Items	Mechanics	Heat	Sound	Light	Electricity
Heat Engines		1			
Cooling due to Expansion		1			
Heat of Vaporization		1			
Coefficient of Expansion		1			
Specific Heat		2			
Change of Boiling Point		1			
Form B					
Fact Items					
English System	1				
Metric System	5				
Ultra-Violet Light				1	
Illumination Candle power				1	
Boiling Point of Water		1			
Compass					1
Amperes					1
Ohm's Law					1
Electrolysis of Water					1
Power	1				
Barometer	4				
Water Wheels	1				
Resultant of forces	1				
Hookes Law-Elasticity	1				
Kinetic Energy	1				
Newton's First Law	1				
Conservation of Energy	1				
Source of Sound			1		
Spherical Mirrors				1	
Thermometer Scales		1			
Transmission of Heat		2			
Relative Humidity		1			
Heat of Fusion		1			
Coefficient of Expansion		2			
Humidity		1			
Form B Thought Items					
Metric System	2				
Fluid Pressure	1				
Displacement of floating bodies	2				
Displacement of sinking bodies	1				
Specific Gravity of fluids	1				
Sideways Pressure	1				
Atmospheric Pressure	7				
Boyles Law	2				
Measurement of Atmospheric Pressure	1				
Resultant of Forces	1				
Component forces	1				
Freely falling bodies	2				
Reflection of Light Color				1	
Images in a Plane Mirror				3	

Hurd's Test Thought Items	Mechanics	Heat	Sound	Light	Electricity
Laws of Reflection				1	
Hot Water Heating System		1			
Thermometers		1			
Change in volume when ice melts		1			
Transmission of Heat		1			
Condensors-Leydon Jar					1
Magnetic Effect of an Elect. Current					1
Generators					1
Conductors of Electricity					1
Ohm's Law					2
Wheel and Axle	1				
Principle of Moments	1				
Pullies	1				
Efficiency	1				
Mechanical Advantage	2				
Intensity of Sound			2		
Lens-Images				2	
Pascals Vases	1				
Water Gauge	1				
Motion	1				
Transmission of Sound			1		
Velocity of Sound			1		
Laws of Strings			1		
Distillation of Water		1			
Boiling Temperature		1			
Conductors of Heat		1			
Specific Heat		1			
Work Done	1				
Relative Humidity		1			
Change F. to C.		1			
Fact Items Form C					
Metric System	2				
Metric to English	1				
Weight of cu. ft. of water	1				
Law of Reflection				1	
Spectrum				1	
Length of Light Rays				1	
Thermometer		3			
Absolute Scale		1			
Volts					1
Voltmeter					1
Transformer					1
Magnetism by induction					1
Efficiency of an El. Lamp					1
Efficiency of a machine	1				
Uses of a Barometer	1				
Water seeks its own level	1				
Density	1				
Displacement-Submerged	1				
Equilibrium	1				
Hooke's Law	1				
Potential Energy	1				
Energy	1				

Hurd's Test
Fact Items
Form C

	Mechanics	Heat	Sound	Light	Electricity
Index of Refraction				1	
Specific Heat		1			
Evaporation		1			
Measurement of Heat		2			
Heat of Vaporization		2			
Charles Law		1			
Form C Thought Items					
Metric System	3				
Metric to English	1				
Pascals Principle Application	1				
Specific Gravity	1				
Spec. Gravity-Floating Body	1				
Fluid force	1				
Sideways force	1				
Atmospheric Pressure	7				
Boyles Law	1				
Mercury Barometer	1				
Resultant of Force	1				
Component of forces	1				
Potential Energy	1				
Motion	2				
Curved Mirrors				1	
Lens-focal length				1	
Expansion due to heat		1			
Coeffident of Expansion		1			
Specific Heat		2			
Compass					1
Magnetic Substance					1
Electrolysis					1
Magnetic Effect of a Current					1
Resistances in parallel					1
Transformer					1
Ohm's Law					1
Screw	1				
Principle of moments	1				
Efficiency of a machine	2				
Work done	1				
Power	1				
Mechanical Advantage	1				
Quality of Sound			2		
Images Curved Mirrors				3	
Lens-Images				3	
Liquid Pressure	1				
Beats			1		
Velocity of Sound			2		
Echos			1		
Laws of Strings			1		
Centrifugal Force	1				
Radiation		1			
Heat of Fusion		1			
Change F to C		1			
Charles Law		1			

Name of Test: Stewart-Ashbaugh Physics Test
Author: A. W. Stewart
E. J. Ashbaugh
Publishers: Public School Publishing Company
Date of Publication: 1931

The authors of this test are A. W. Stewart of Kent State college and E. J. Ashbaugh, Miami University. These tests are divided into four forms; two on mechanics and heat, and two on electricity, sound, and light. This division is made on the usual high school course of study.

These tests are items concerning the application of physics, and contain only thought items. The distribution of questions does compare very favorably with the table given at the end of this section on the percentage composition of eleven text books. This is one of the recent tests and shows the effect of recent developments in the testing field concerning physics.

The type of questions used in this examination is the controlled completion. An illustration of the type of question is given by the following sample taken from one of the tests. The directions are as follows. "Fill the blanks and answer the questions with word groups chosen from the columns at the right, always indicating your choice by placing the proper number in parenthesis.

( ) 1. The motion of the earth is----------

( ) 2. A liquid in a capillary tube is acted by three forces, 7, 8, 9. If the liquid rises in the tube, which one of the forces will be greater?

( ) 3. If an object slightly displaced tends to recover its position, it is said to be in

( ) 4. A base ball lying on a smooth level surface is in

1 Neutral Equilibrium
2 Stable Equilibrium
3 Unstable Equilibrium
4 Uniformity accelerated motion"
5 Uniform
6 Negatively accelerated motion
7 Adhesion
8 Cohesion
9 Gravity"

This is slightly different from the general run of tests in that it tests the ability to associate a device or process with the physical principles which it involves, as well as testing the meaning of physical terms, the understanding of physical laws, and the solution of simple problems.

There is no mention of a coefficient of correlation for validity mentioned in the sheet accompanying the test. In attempting to show some semblance of validity the authors state that, "The test covers the topics usually included in a high school course. The questions have been chosen after several years of use in the class room. All items in the test have been checked over by a class of graduate students in education and by the head of the physics department in a state university." They, say, also, that they have checked the questions in the test against the material in several current text books, but fail to mention the texts used.

The reliability coefficient of the tests on mechanics and heat were found by giving both forms of the test to the same 104 pupils and correlating the two sets of scores against each other. The coefficient of reliability was found to be .71 with a probable error of $\pm$.03. In the case of electricity, sound, and light which was correlated the same way with 113 pupils taking the test, the reliability coefficient was .80 with a probable error of $\pm$.02. They also mention the fact that, if both forms are used, a higher reliability is predicted by using Brown's formula.

The norms evidently are based on varying numbers of pupils. The authors mention twelve high schools the students of which took the examinations. The norms as given are as follows:

TABLE NO. 34

Mechanics and Heat

	Form 1	Form 2
75th percentile	35.5	36.7
50th percentile	29.9	30.7
25th percentile	21.8	24.8
N	221	319

Electricity, Sound & Light

75th percentile	38.1	37.8
50th percentile	30.9	30.4
25th percentile	23.8	24.3
N	205	175

The scores should be interpreted as follows. All pupils making a score of over 35.5 on Mechanics and Heat, Form 1, indicate that they rank in the upper quarter of those that have taken the test. Other scores may be interpreted in the same way.

The directions for the testing of the examination are adequately given on each examination sheet itself. A number of samples are given to show how it should be done. The pupils are not to open the examination book before being told by the instructor, and then they are allowed just thirty-five minutes in which to complete it.

A scoring key accompanies each set of examination papers and the test is so arranged that it is easy to score. Class record sheets are provided with the examinations.

The cost of the examination is as follows: Price, 50¢ per package of 25 copies of any one test and form. Each package also contains a direction sheet and class record sheet (with answers). Sample set, one form of each test, 15 cents.

TABLE NO. 35

Thought and Fact Items in Stewart-Ashbaugh Physics Test

Total number of questions	loo
Number of thought items	loo
Percentage of thought items	loo
Number of fact items	o
Percentage of fact items	o

TABLE NO. 36

Comparison of Percentage Composition of Stewart-Ashbaugh Physics Tests with the Mean as to Percentage Composition of Eleven Text Books

	percentage books	composition of test
Mechanics	33.64	29.00
Heat	14.53	20.00
Sound	7.14	10.00
Electricity	31.10	28.00
Light	13.38	13.00

TABLE NO. 37

The Distribution of Thought and Fact Items According to Subject Matter in Stewart-Ashbaugh Physics Test

Thought Items	Mechanics	Heat	Sound	Light	Electricity
Uniform Motion	1				
Capillary Action	1				
Stable Equilibrium	1				
Neutral Equilibrium	1				
Relative Humidity	1				
Heat of Fusion		3			
Coefficient of Expansion		2			
Friction	1				
Heat of Vaporization		1			
Specific Heat		2			
Steam Engine		1			
Steam Turbine		1			
Automobile-Carburator		1			
" Ignition					1
Eccentric gears	1				
Newton's First Law Inertia	2				
Transfer of Heat-Conduction		1			
" " Radiation		2			
" " Convection		2			
Dew point		1			

Stewart-Ashbaugh Test Thought Items	Mechanics	Heat	Sound	Light	Electricity
Mixtures Heat		1			
Newton Fluid Law-Reaction	1				
Newton Law of Gravitation 3rd	2				
Centrifugal Force	1				
Newton 2nd Law Momentum	2				
Fluid Pressure	2				
Hookes Law	1				
Boyles Law	2				
Input and Output of Machines	1				
Motion-Distance covered	1				
Pendulum	2				
Levers	1				
Fahrenheit to Centigrade		1			
Efficiency of machines	1				
Inclined Plane	1				
Charles Law		1			
Density	1				
Freely falling bodies $S = \frac{1}{2} G t^2$	1				
Sympathetic Vibration			1		
Characteristics of Mus. Sound					
Amplitude			1		
" "					
Pitch			1		
Galvanometer					1
Transformers					2
Induction Coil					1
Generators					1
Wheatstone Bridge					1
Rectifier					1
Electrical Measuring Ins.					1
Magnetos					1
Electrophorus					1
Conductors of Elec.					1
Condensors					1
Telephone receiver					1
Rheostats					1
Electroscope					1
Electric Bell					1
Voltmeter					1
Ammeter					1
Electric Bell--Internal Resistance					2
" Polarization					1
" Local Action					2
" Voltage					1
Lens Images				5	
Phonograph			1		
Vibrating Reed			1		
" Lips			2		
Pipe Organ			1		
Refraction				1	
Dispersion thru a prism				2	
Spectra				1	
Chromatic Abberation				1	
Resistance in Series					1
Laws of Resistance					1
Cost of K. W. H. Elec.					1
Vibration Frequency			1		
Laws of Strings			1		

Stewart - Ashbaugh Thought Items	Mechanics	Heat	Sound	Light	Electricity
Index of Refraction				1	
Resistance in Parallel				1	
Photometer				1	

Name of Test: Black and Cushing--A Test in Applied Physics

Authors: N. Henry Black
Burton L. Cushing

Publishers: Ginn and Co.

Date of Publication: To be published

This test is the product of N. Henry Black and Burton L. Cushing of Harvard University. The test is still in its preliminary edition.

The set up of the examination is very good. It is intended to be a test in the application of the fundamental laws of physics. Hence the questions are all of the thought type. If a teacher is looking for this type of test, this would be an ideal one. It compares very favorably with the percentage composition of eleven text books and consequently is a well balanced test.

At present there is no information on the test available as to reliability, validity or norms. Ruch & Myer[1] in correlating the scores yielded on six examinations to find validity found that Black and Cushing was higher than the others. They also found the reliability coefficient to be .81 based on 132 cases.

There are two forms of the test with fifty items each. The multiple choice type of question is used.

Directions for giving the examination are printed on each examination paper. The score is the number of correct responses.

The purpose of the test is, according to the authors, to measure the pupils' mastering of the fundamental principles of physics by testing the ability to recognize the underlying physical principles which explain certain common applications of the science.

There is no information on the price as they had not been published when this article was written.

1. Ruch, G. M. and Meyer, S. A. Comparative Merits of Physics Tests School Science and Mathematics Vol. 31, 1931 p.p.676-680

TABLE NO. 38

Thought and Fact Items in Black and Cushing Test in Applied Physics

	Form A.	Form B.
Total number of questions	50	50
Number of thought questions	50	50
Percentage of thought questions	100%	100%
Number of fact items	0	0
Percentage of fact items	0	0

TABLE NO. 39

Percentage Composition of Black & Cushing Test in Applied Physics as Compared to the Mean Percentage Composition of Eleven Physics Text Books

	Percentage composition of books	Form a	Form b
Mechanics	33.64	36	36
Heat	14.53	18	16
Sound	7.14	6	6
Electricity	31.10	30	30
Light	13.38	10	12

TABLE NO.40

The Distribution of Thought and Fact Items According to Subject Matter in Black and Cushing Test in Applied Physics

Form A Thought Items	Mechanics	Heat	Sound	Light	Electricity
Conductors of Heat		1			
Suction Pump	1				
Stability of a body	2				
Coefficient of Expansion		1			
Beats			1		
Conductors of Electricity					1
Transfer of Heat-Radiation		1			
Parallelogram of Force	1				
Speed of Light and Sound				1	

Black and Cushing

Form a Thought	Mechanics	Heat	Sound	Light	Electricity
Gold Leaf Electroscope					1
Electrolysis					2
Radiation of Heat in Cooling Bodies		1			
Steam Heating System		1			
Earth's Magnetic Field					1
Fluid Pressure	1				
Evaporation		1			
Storage Battery					1
Potential Energy	1				
Bunsen Photometer				1	
Connections in Parallel					1
Cooling due to melting		1			
Polarization in a cell					1
Human eye				2	
Electric Bell					1
Automobile Induction Coil					1
" Clutch	1				
Efficiency of a machine	1				
Wheel and axle-Lever	1				
Images in a Plane Mirror				1	
Mechanical Advantage	1				
Displacement floating bodies	1				
Stress and Strain	1				
Hook's Law	2				
Mixtures Heat		1			
Pendulum	1				
Sympathetic Vibration			1		
Storage Battery					1
Electro-Magnet use					1
Hot Water Heat System		1			
Images in Curved Mirror				1	
Static Charging by induction					1
Ammeter Voltmeter					1
Dispersion of Light Thru Prism				1	
Automobile Differential	1				
Screws	1				
Equilibrium	1				

Form B Thought

Electro-magnets					1
Pullies	1				
Transfer of Heat Conduction		1			
Hydraulic Press	1				
Freezing by Melting		1			
Radio					1
Levers	1				
Expansion Due to Freezing of Water		1			
Ammeter					1
Transfer of heat Convection		2			
Motors Series					1
Generators					2
Boiling point due to pressure		1			
Transfer of Sound			1		
Potential Energy	1				

Black and Cushing
Form B

Thought	Mechanics	Heat	Sound	Light	Electricity
Laws of Strings			1		
Image in a convex lens				1	
Barometer	1				
Evaporation		1			
Heat Effect of a Current					1
Colors				1	
Resistance to A Flow of Current					1
Indirect Light				1	
Intensity of Illumination Ft. Candles				1	
Mechanical Adv. of Machines	1				
Line Losses in Elect. Current					2
Automobile Cam Shaft Gears	1				
Component and Resultant Forces	2				
Newton 1st Law Inertia	1				
Siphon	2				
Screws	1				
Barometer	1				
Molecular Theory of Matter	1				
Gas Engines Cooling		1			
Natural Periods of Vibration			1		
Telephone Transmitter					1
Relay in Telegraph Circuit					1
Hot air Heaters		1			
Image-Concave Mirror				1	
Spark Gap					1
Chromatic Aberration				1	
Electric Cell-Dry					1
Cells Local Action					1
Automobile Clutch	1				
Centrifugal Force	1				

A Table of Examinations

In the following pages the writer has attempted to give a table by which the reader may compare the different examinations that might be used as a final examination in high school physics. These questions are classified under a broader head than the previous tables that have been given. It is hoped that it may be of some aid in evaluating and criticising the tests published. The teacher who is searching for a test may, by consulting this table, determine whether all of the topics taken up in his course of study are represented by questions in any particular test. It will also show whether the test is best suited to help the particular pupils involved. The writer is indebted to Dr. G. M. Wilson of Boston University for the plan for the make up of this table, and the previous tables; and for the suggestion that it might be a concise way of picturing the examinations so that a teacher might more readily criticize and evaluate a specific test.

Mechanics	Hughes - Thought R Division I	Hughes - Thought R Division II	Hughes Physics Scales Information R. Division I	Hughes Physics Scales Information S. Division II	Stewart - Ashbaugh Physics Test	Black and Burlingame Test - Form A	Black and Burlingame Test - Form B	Starch's Physics Test	Iowa Physics Test Form I	Hurst Test in High School Physics	Black and Cushing - Test in Applied Physics Form A	Black and Cushing: Test in Applied Physics Form B	Iowa Placement Examinations - Physics Training I	Jones Union Physics Test	Thurstone's Vocational Guidance Test: Physics	Columbia Research Bureau Physics Test Form A	Columbia Research Bureau Physics Test Form B	Michigan Instructional Tests in Physics - Final Exam. Form A	Hurd's Final Test in High School Physics Form A	Hurd's Final Test in High School Physics Form B	Hurd's Final Test in High School Physics Form C
Matter and Energy					1	1	1	1		6			1					2			
Properties of Matter				1				1		4	4	1	1		2						
Physical Measurements		1	1			2				14			3			2	2	6	9	8	8
Molecular Motion										6						1					
Surface Phenomena		1	1		1		1	2		4			1					2			
Pressure of Fluids	1				4	2	3	2		9	1		4		3	8	8	3	4	4	4
Turbines and Waterwheels					1					1										2	
Bodies Immersed in Liquids	1					1	2			7	1		1			6	6	1		4	1
Density and Specific Gravity	1	1			1	4	4	2	1	16			3		1	2	2	3	5	1	3
Pressure of the Atmosphere				1		4	3	2	2	19	1	4	2			4	1	3	4	4	6
Compression and Expansion of Gases							2	1	1	6			2		1	1	1	3			1
Pneumatic Appliances					1						1		1					1	6	6	7
Motion in Straight Lines			1		3	2	1	1		5		1	1					3	2	1	2
Curvilinear Motion				1	1										1	1	1				
Measurement of Force					1	1	1	1		3				3		12	14	2	1		
Composition of Forces and of Velocities	2	1					2	2		5	1		1	4	1			1		2	3
Newton's Laws of Motion	1	1		1	4	1		3		8		1	2			2	1		1	1	
Gravitation		1	1			1				2			1	1	1	1	1	1			
Falling Bodies	2				5		1	2		2	3			3			4	3	1	2	

	Hughes - Thought R Division I	Hughes - Thought S Division II	Hughes Physics Scales Information R - Division I	Hughes Physics Scales Information S - Division II	Stewart - Ashbaugh Physics Test	Black and Burlingame Test - Form A	Black and Burlingame Test - Form B	Starch's Physics Test	Iowa Physics Test Form I	Hurst Test in High School Physics	Black and Cushing Test in Applied Physics Form A	Black and Cushing Test in Applied Physics Form B	Iowa Placement Examinations - Physics Training I	Jones Union Physics Test	Thurstone's Vocational Guidance Test: Physics	Columbia Research Bureau Physics Test: Form A	Columbia Research Bureau Physics Test: Form B	Michigan Instructional Tests in Physics: Final Exam. Form A	Hurd's Final Test in High School Physics: Form A	Hurd's Final Test in High School Physics: Form B	Hurd's Final Test in High School Physics: Form C
Centripetal and Centrifugal Force			1	1						2		1				1			1		
The Pendulum					2			2	1	2	1							2			
Work and Energy	3				1	3	1	2	1	16			6	4	1	3	3	2	3	4	4
Potential and Kinetic Energy							1	1	1	8		1	4	3		3	2	2		1	1
Machines	1	2			4	4	1	3	4	17	5	8	4	7	4	4	1	1	5	6	5
Efficiency of Machines							2		1	4	1		3	1			2		1		1
Sound																					
Wave Motion		1								1								1		1	
Sound and its Transmission							2			2			2	2		4	2	1	1	2	1
Velocity of Sound	2	1	1	1		1		1		9	1		2		1	1		1			
Reflection of Sound	1									1			1	1		1	1				1
Resonance					1					1	1	1									
Characteristics of Musical Sounds					2	1	1	3		6		1	2	1		3	3	1	3		3
Interference and Beats			2	1				1			1		1	1				1		2	1
Musical Scales		2			1													1	1		
Vibration of Strings		1	1	2	1			4		2		1		3		1	1	2	1	1	1
Vibration of Air Columns					5	1								2		1	1	1	1		
Light																					
Nature and Transmission of Light			2			3	2	1		16			4			1	5	1	1		
Photometry			1		1	2	1	2		10	1	2	2	3		2	1				
Reflection of Light	1			1				1		6			1		1	2	2			1	1
Refraction of Light				1	3		1	2		8			1			5	8	3	1		1

	Hughes - Thought R Division I	Hughes - Thought S Division II	Hughes Physics Scales Information R. Division I	Hughes Physics Scales Information S. Division II	Stewart - Ashbaugh Physics Test	Black and Berlingame Test - Form A	Black and Berlingame Test - Form B	Stark's Physics Test	Iowa Physics Test Form I	Hurst Test in High School Physics	Black and Cushing Test in Applied Physics Form A	Black and Cushing Test in Applied Physics Form B	Iowa Placement Examinations: Physics Training I	Jones Union Physics Test	Thurstone's Vocational Guidance Test: Physics	Columbia Research Bureau Physics Test Form A	Columbia Research Bureau Physics Test Form B	Michigan Instructional Tests in Physics - Final Exam. Form A	Hinds Final Test in High School Physics - Form A	Hinds Final Test in High School Physics - Form B	Hinds Final Test in High School Physics Form C
Mirrors	2	1					1			5	1	1	1	3		3	1	5		5	4
Lenses				1	5	1	3	1		5	2	1	2	4	2	5	4		5		1
Optical Instruments											1					1	2		3		3
Dispersion		1		1	3	2		1		3	1	1	1			1	2	3	1	1	1
Color		1						1		10		1	1					2	1	1	1
Interference and Diffraction				1						1											
Heat																					
Heat and Temperature			1			1	1			5			1					3	2	3	1
The Thermometer		1		1	1		1	2	1	13			2	24		2	4	2	1	4	4
Expansion and Contraction		2			6	1	1	1	2	12	1	1	4	5		4	5	2	4	3	4
Measurement of Heat	1	1	1		2	1		4	1	16			2	67	1	2	3	4	5		6
Change of State			1	2	4	1	3		3	19	2	1	4			6	4	3	8	3	2
Transmission of Heat	2				5		2	2	3	10	6	4	5			3	3	4	1	6	1
Heat and Work						4				5		1		5		2	4			1	1
Humidity and Dewpoint					2	1				3		1	1					3	1	4	
Electricity and Magnetism																					
Magnets and Magnetic Action		1	2	2						6	1		2			4	4	3	1	1	1
Nature of Magnetism										8			2					2	1		1
The Magnetic Field					2	1			3						1		1			1	
Static Electricity		1		2	1				1	5			3				1	1	1		
Conductors and Non-Conductors				1	1	1			1	4		2	3			1	1	2		1	
Electrostatic Induction			1	1	1				1	5	2					1	1	1	1		
Electric Potential								1		1			1					1			
Electrical Capacity and Condensors					1		1	1		4			1			3		2		1	

	Hughes - Thought R Division I	Hughes - Thought S Division II	Hughes Physics Scales Information R. Division I	Hughes Physics Scales Information S Division II	Stewart - Ashbaugh Physics Test	Black and Burlingame Test - Form A	Black and Burlingame Test - Form B	Starch's Physics Test	Iowa Physics Test Form I	Hurst Test in High School Physics	Black and Cushing Test in Applied Physics Form A	Black and Cushing Test in Applied Physics Form B	Iowa Placement Examinations: Physics Training I	Jones Union Physics Test	Thurstone's Vocational Guidance Test: Physics	Columbia Research Bureau Physics Test Form A	Columbia Research Bureau Physics Test Form B	Michigan Instructional Tests in Physics Final Exam. - Form A	Hurd's Final Test in High School Physics Form A	Hurd's Final Test in High School Physics Form B	Hurd's Final Test in High School Physics Form C
Electric Machines										1											
Cells	1			2	6	1	2		1	11	1	2	1			5	6	3			
Electrolysis			2			1	1	1		7	4		2			5	2	3		1	1
Ohm's Law and its Applications		3	3		2	1	3	6	3	9		1	3	1	4	5	3	3	2	2	1
Connection in parallel and series		3			2					3	1		2	6		1	5	1	1	2	1
Heating Effects of a Current	1					2	1			7		1	3	2		1	2				
Coulombs and Measurement of Quantity		1	1					1	2				2	2				1			
Electromagnets	1										1	1	1			3	3	1		1	
Measuring Instruments					5	1		2	2	1	1	1	4			2	2	2			1
Measurement of Power			1	1	1		1	3		7			3	4	1	3	3		1	1	1
Electromagnetic Induction										13			1			2	2	3			1
Generators	1		3		1	1	2	3		7		2	1			1		1	1	1	
The Induction Coil		1			1			1		5	1										
Radioactivity and Electrons			1	2		2	2			13			6			3	1	1	1		
Direct Current Machines	2			1	2	1		1		3		1				1	2	1			
Transformers		1		1	2	1	1	1		4		1							1		2
Telegraph and Electric Bell			1		1					2	1	1				1					
Telephone					1					5		1									
Wireless and Radio												2	1								

CHAPTER VI

CONCLUSIONS

There is no doubt that the new type test is here to stay. It has been in use now in the field of physics for at least twelve years. During that time it has emerged from tests that were given no credence by physics teachers to tests that we fully recognized as having a definite place in our testing program. It has proved particularly applicable to physics where the old, essay type is tedious for the student to answer and for the teacher to correct. The new-type involves knowledge of facts and knowledge of how to apply these facts in situations that occur in every day life. In the old type examination the teacher was forced to wade through a useless lot of material to get at the facts desired. Then, too, the reliability and validity of the old type test is never very high at its best. The new type examination certainly presents a better means of testing than the essay type. A combination of the various types of questions presented previously by the writer will prove to be surer, truer, more beneficial means of testing and a simpler one to score.

This type of examination question is being taken up by the College Entrance Examination Board which may serve to alleviate the fears of some teachers who have thought that this objective test did not prepare the student to take College entrance examinations.

During the time that the new type examinations have been in use a greater part of the time has been spent in examinations to test achievement. There are however two other important uses of these tests. They are prognosis and diagnosis.

There is a wide field for research in the field of prognostic tests. There are really only two of this type published in the field of physics. These that have been prepared present results that are only slightly better than guesswork. The question of predicting success in physics certainly involves a number of things. The problem is then to isolate these factors that contribute to success and then to formulate them into a test that will truly have predictive value.

The tests for use in diagnostic and remedial work are yet in their infancy, too, although more advanced than those for prognosis. In the last few years there have been a number of tests published with this end in view. Among these are Hurd's Workbook, Glenn-Obourn Instructional Tests, and the Michigan Instructional Tests. A. W. Hurd states that the work book tends to help the pupils help themselves (1) by showing them tasks, the accomplishment of which will help them in the achievement of the larger objectives of education and (2) by indicating the nature of the specific steps to be taken in the accomplishment of these tasks.[1] At the end of this work book are tests on each of the separate sections. The instructional tests are merely tests that are given at the end of a section, the weaknesses noticed and remedial work given. There are still, however, a great many problems for research still in this field.

The new type test serves to remove partially one of the outstanding inefficiencies of school systems. No other business is run without some means of accurately measuring the product thus produced. Why, then, should we attempt to teach without some method of measuring results? The new type tests furnish us with an opportunity to judge the finished product in a purely impersonal manner.

1. Hurd, A. W. "The Workbook as an Instructional Aid" School Review 39: p.p. 608-616 No. 8 1931

1. Tiegs, E. W. "The Workbook as an Instructional Aid" School Review 39: pp. 608-616 No. 9 1931

A great many of the teachers think that there is no objective test other than the standardized test. This is, however, a fallacy that should be righted. Informal new type tests have a definite place in the testing plan. Consequently we should have a more scientific method of approach in constructing them. Too many that are a disgrace to the new type name are made out by unexperienced teachers. It has been the purpose of the earlier part of this thesis to present a brief but rather inclusive method of constructing examinations of this type.

Even a great many of the standardized tests of today will bear improvement. It must be admitted that less than a half dozen of those so called tests are tests in more than name only. Few have been carefully validated against a good outside criterion. Adequate norms are available only in isolated cases. Probably the more technical issue of reliability (in the sense of self-correlation) has not been raised in more than four or five cases[1] in tests published up to 1923. It is a source of gratification however, that recent tests in physics are far more scientific and more sound than were some of the earlier tests. A criteria for estimating the value of so-called standardized tests has been established earlier in this thesis, and it was the intention of the writer to list all available published tests in physics, with comment on each one in an earlier part.

It is not claimed that the new-type test is a panacea for all the ills of education, but it does have its own peculiar functions, and a well defined place in the program of testing. It is, moreover, the best that has come to our attention and by far the most efficient.

The essay type also has its particular uses, and by a judicious use of both we should be able to get far better results than we have ever before.

1. Ruch, G. M. School Science & Mathematics 23: p.p. 885-891 1923

APPENDIX . SECTION I

MISCELLANEOUS TESTS

There have been several good remedial and instruction tests, and work books published recently. Among these are the Glenn Obourn Tests and the Michigan Instructional tests. These cannot be classified as final examinations although they can be listed as standardized because they have all the qualifications of a standard test. A description of these is enclosed in this section on miscellaneous tests in physics.

A new venture has been undertaken in the field of physics by Kirkpatrick and Greene, who have published a manual of new type questions from which a teacher may make up his own examination. At the present time they have succeeded in covering only the field of mechanics but other hand books are to follow in other subjects such as heat, sound, electricity and light. A description of this book is also included in this section.

A work test book in physics has been published by A. W. Hurd. This book besides serving as a work book, also presents a type of remedial test which is to be given at the end of each section. A description of this, too, is included here.

To complete this section the writer has included all tests on physics that he has been able to locate through their being mentioned in any publication.

Name of Test: Glenn-Obourn Instructional Tests in Physics
Author: Earl A. Glenn
Ellsworth S. Obourn
Publisher: World Book Company
Date of Publication: 1930

These tests were prepared by Earl R. Glenn of the New Jersey State Teachers College and Ellsworth S. Obourn of the John Burroughs School, Clayton, Missouri. The set is composed of twenty five tests covering the following topics; Mechanics, Heat, Light, Sound, and Electricity and Magnetism. The types of questions used are the brief answer, the completion, the multiple choice and association types. The first four are used in the general body of the test, one type predominates in each test, and the association is used in the vocabulary tests one of which accompanies each test. The title of each of the tests together with the predominating type of questions and the number of questions follows.

TABLE NO. 41
Table of Test Titles with Type and Number of Items of Glenn-Obourn Instructional Tests

No. of Test	Title of Test	Main Type of Item	No. of Items
1	Measurement of Length, Time, Weight and Density	M.C.	23
2	Liquid Pressure and Pascale's Law	B.A.	28
3	Archimedes' Principle and Specific Gravity	C.	35
4	Air Pressure and Pneumatic Devices	B.A.	36
5	The Molecular Theory of Matter	T.F.	45
6	Energy, Force and Motion	C.	67
7	Work, Power, and Simple Machines	C.	54
8	Temperature Measurements and Expansion Phenomena	B. A.	36
9	Transformations of Work & Heat Energy	B. A.	40

No. of Test	Title of Test	Main Type of Item	No. of Items
10	The Phenomena of Melting & Boiling	T.F.	50
11	Conduction, Convection, & Radiation	B.A.	31
12	Magnetic Phenomena	M.C.	25
13	Static Electrical Phenomena	T.F.	50
14	Measurement of Electric Currents	M.T.F.	40
15	Heating & Lighting Effects of Electric Currents	B.A.	35
16	Magnetic & Chemical Effects of Electric Currents	M.C.	30
17	Induced Currents, Dynamos, and Transformers	B.A.	38
18	The Nature & Transmission of Sound	M.T.F.	40
19	Musical Scales and Instruments	B.A.	40
20	The Nature & Transmission of Light	M.C.	30
21	Mirrors, Lenses, & Optical Instruments	C.	44
22	The Phenomena of Color	B.A.	41
23	Invisible Radiations	T.F.	40
24	The Automobile	C.	40
25	Wireless & Radio Communication	M.T.F.	35

M.C. Multiple Choice, T.F. True-False, M.T.F. Modified True-False, B.A. Brief Answer, and C Completion.

The purpose of the examinations as stated by the authors in brief is (1) to make it possible to identify some of the learning difficulties of the student, (2) to reveal the nature of the errors made by students, (3) to make a frequent survey of the students' successes and failures with a reasonable expenditure of time, (4) to provide for an intelligent drill program for remedial work, (5) to reveal the nature of the pupils achievement, (6) to provide a means of presenting problems for research work.

The validity of these tests was provided for by analysis of widely used high school physics text books and the commonly used first year college text books, the subject matter of the questions asked by the College Entrance Examination Board, of vocabularies used in physics, and a special analysis of the diagrams in high school text books. They were further validated by correlating the result obtained in the examinations against the school marks given by the teacher in the subject of physics. By correlating the mark given by an expert teacher with the results from these examinations, the correlation may be expected to exceed .80. When the composite scores were correlated with achievement test scores, they were found to range from .60 to .75. The marks of the students who score high in these tests, when compared with later courses in physics, show that these same students obtain high grades in the advanced work. The questions in these examinations were also submitted, at Teachers College in Columbia University, to a group of graduate students who taught physics, for criticisms which would further increase their validity.

The reliability coefficients on these tests based on odd and even items and corrected by Brown's Formula range from .70 to .88 with probable errors ranging from .04 to .01. The above results were obtained on the experimental edition and the authors state that there is reason to believe the reliability will be higher on this edition due to the improvements made since the experimental edition was used. These results would indicate that the reliability would be good enough for a class average but there might be some doubt as to the reliability of a single score.

The administration of these tests is not at all difficult. Directions are given in the manual that are to be read to the class before the books are given out. A paragraph heads each test instruc-

ting the pupil as to what he is to do. The first time that a type of question is used in a test, illustrations are given. This might be somewhat of a handicap if the tests were not given in the order given in the book. This difficulty ought to be over-come with a constant repetition of the type of questions used.

Scoring is comparatively simple. A scoring key is furnished, spaced so that the answer comes opposite the response. The tests are claimed to be highly objective, and may be corrected by a clerk. The authors suggest that the correcting be done by the pupils in the class room. The error will not be over 1 or 2 per cent and the pupils get the added benefit of learning what the correct response should be. He then goes over his own paper, discovers errors, and makes corrections immediately thus increasing their teaching value.

There is no instructions in the true-false questions that the pupil is not to guess. Nevertheless, this type of question is corrected by the right minus wrong method. This might somewhat impair the reliability of the scores obtained.

There is no time limit for the tests and the time required undoubtedly varies with the examinations. In the writer's experience the length of time required to do some of the longer tests is greater than the customary 40 minute period and consequently this limits their use somewhat.

Norms are presented in the manual in the form of percentiles running from 5 to 95, intervals of tens from 10 to 90. There are no duplicate forms of the examination, but this fault is probably balanced by the large number of tests.

The cost of the tests is 32 cents for the booklet with the twenty-five tests, the scoring key 12 cents, teacher's manual 15 cents. These prices are subject to discount.

"ame of Test: Hurd's Work-Test Book in Physics
Author: A. W. Hurd
Publisher: MacMillan Company
Date of Publication: 1930

This work-test book is the product of A. W. Hurd of the Institute of School Experimentation, Teachers College, Columbia University. The book consists of 19 units and 19 tests, one for each unit. Each unit consists of references, work for all of the pupils to do, and projects that may be followed. The work for all the pupils is in the form of a type of completion question. The materials in the units are shown by the following titles.

TABLE NO. 42

Titles of Units in Hurd's Work-Test Book

No. of Unit	Name of Unit
1	The Hydrometer as a Measuring Device
2	Machines and Their Value
3	Applications of the Principles of Liquid and Gas Pressure in Water and Gas Supply Systems
4	Applications of the Principles of Fluid Pressure in Water and Aircraft.
5	Heating, Ventilating and Humidifying Systems
6	Refrigeration and other Applications of Heat Energy
7	Atmospheric Electricty and Some of its Manifestations
8	Electric Lighting System
9	Electrical Generation and Transmission
10	Electricity in Communication
11	The Storage Battery and Electro-Chemistry
12	Photography and Picture Projection
13	Telescopes and Miscropes
14	Light Projectors
15	Color and Some of its Phonemena
16	Musical Instruments as Applications of the Laws of Sound
17	X-Rays and Other Radiations
18	Some Simple Manifestations of Gravity
19	The Automobile

While these topics do not seem to cover the course of physics as it is generally followed, the writer, upon careful study of the book, finds that it differs in no way for the ordinary prescribed course. The plan that is followed is the presentation of a topic and the other ideas are brought in as occasion develops in the process of the discussion of the original topic. This is really putting into practice the generalizations laid down in the National Year Book of the N. E. A. for 1932.

There are three types of questions; the brief answer, the multiple choice, and the completion. The directions for taking the examinations are given at the beginning of the set of tests and no illustrations are given. There is no manual accompanying the work book.

The fault of the examinations is that they are in the book which the pupil is working with all the time. He naturally sees the questions, and even may look up the answers before he takes it. This may be overcome by tearing out all of the tests before the books are placed in the hands of the pupils.

The value of the first part of the book is that the student learns facts that he is later tested on by testing himself to determine whether he has mastered them or not.

The scoring is easy, the answers being in a direct line at the right hand side of the page. There is no scoring key sold with the books. The score on the test is generally the number of correct responses.

The cost of the book is 64 cents without the discount deducted.

Name of Test: Kirkpatrick and Greene's Pupil-Teacher Handbooks of Objective Test Exercises in High School Physics

Author: J. E. Kirkpatrick
Harry A. Greene

Publishers: Public School Publishing Co.
Date of Publication: 1931

This set of objective tests was prepared by J. E. Kirkpatrick of the West Liberty High School, West Liberty, Ohio, and Harry A. Greene of the University of Iowa. At present the only one published is a set of questions on Mechanics, but other sets are to be published and the keys and instructions are furnished in the manual for exercises on Mechanics, Sound, Heat, Light, and Electricity and Magnetism.

The handbook on mechanics presents items on all the important topics and phases of this subject. Each concept is presented, where possible, in four different objective test forms, which are true statements, false statements, simple recall exercises, and multiple choice exercises. It is the intent of these questions to cover every particular phase with thought provoking questions as well as the information type. Test items on the following units comprise the Handbook on Mechanics.

TABLE NO. 43

Table of Subjects Covered by Test Items in Kirkpatrick and Greene's Pupil-Teacher Handbooks

1	Matter and Energy
2	Properties of Matter
3	Physical Measurements
4	Molecular Motion
5	Surface Phenomena
6	Molecular Forces in Solids
7	Pressure of Fluids
8	Bodies Immersed in Liquids
9	Density and Specific Gravity
10	Pressure of the Atmosphere
11	Compression of Gases
12	Pneumatic Appliances
13	Motion in Straight Lines
14	Measurement of Force
15	Composition and Resolution of Forces
16	Newtons' Laws of Motion
17	Gravitation
18	Falling Bodies
19	Centripetal and Centrifugal Force
20	The Pendulum

TABLE NO. 43
Cont'd

21	Work
22	Power
23	Energy
24	Efficiency and Mechanical Advantage
25	Levers
26	Machines (exclusive of Levers.)

This book is intended for the use of teachers who make their own objective examinations. When the teacher wishes to give a test to the class, he selects the exercises covering the particular unit or units of study. He can choose what type of question he wants to give or he can combine two or even three kinds in one examination.

In preparing the items, the following commonly used high school physics textbooks were consulted (1) Carhart and Chute "Practical Physics", (2) Dull "Essentials of Modern Physics", (3) Millikan and Gale "Elements of Physics", (4) Fuller Brownlee and Baker "Elementary Principles of Physics", (5) Henderson "Physics in Everyday Life", (6) Hoadley "Essentials of Physics", (7) Black and Davis "Practical Physics." Items that were not common to at least five of the seven text books were not included. A system of key numbers was devised for the purpose of identifying and describing definitely each test exercise. They were then arranged according to this key number system. All of the items were administered to a class of 42 pupils. On a basis of the scores on the items, they were divided into a good or a poor group. The descriminative power of the items were then investigated, and the incorrect responses were carefully noted. The results of the above were used to revise the exercises to make them more valid and reliable.

Experimental investigations based on random sampling of tests taken from material in the Handbook shows coefficients of reliability from .84 to .95 with an average of .905 for 100 item tests. The number of samples taken, of course, affect the reliability. Using

the Spearman-Brown Prophesy formula would show that, if the number of items were increased to 200, the reliability coefficient could be predicted as .95. The authors state that these results seem to indicate that an examination consisting of from 150 to 250 items of all ranges of difficulty from the very easy to the very hard, and in which approximately one-fourth to one-sixth of the total number of items are problems, can be expected to be answered in a double period of ninety minutes with a reliability of above .90.

The manual gives instructions as to the set up of the examination so that the administration may be easy. They also suggest a method of making out a scoring key with the aid of the key number, which has been mentioned. The score should be the number of correct responses in the simple recall and multiple choice, and the right minus wrong method should be used in the true-false items. The authors suggest uses to which these questions may be put which are the same as any other informal objective test.

One distinct advantage included in the manual is two methods of changing from scores to letter grades. The two methods given are the Standard Deviation Technique and the Normal Curve Technique. The first is by far the more satisfactory but the more complicated statistically, while the second is not so complicated but not so good as the one previously mentioned. However, some teachers prefer the latter method.

The cost of this handbook on Mechanics is $1.00 a copy, postpaid, while the Manual which covers Mechanics and the others that are to be published is 75 cents a copy, postpaid.

Name of Test:	Lapp's Iowa Achievement Examinations in College Physics
Author:	C. J. Lapp
Publisher:	Bureau of Educational Research and Service University of Iowa
Date of Publication:	1926

These tests were prepared by C. J. Lapp of the University of Iowa. The examination consists of two series of eight objective examinations of equivalent difficulty. These eight examinations are divided into three mid-semester, and one final for the first semester, three mid-semester, and one final for the second semester. The mid-semester examinations consist of four pages, each page containing one part. Part I contains thirty or more true-false statements. Part II contains forty or more completion items. Part III contains ten or more items which are generally simple-recall on formulas and symbols. Part IV contains fifteen problems.

This examination follows the presentation of topics as in "Physics, A Text Book for Colleges" by Oscar M. Stewart. There is no information in the manual as to the validation of these tests. The specific topics covered by each of the examinations together with the section covered in Stewart's text book are as follows.

TABLE NO. 44
Topics Covered in Lapp's Iowa Achievement Examinations

Test No.		Paragraphs in Text Book
A--1 or B--1	1st half of mechanics	1 to 105
A--2 or B--2	2nd half of mechanics	105 to 183
A--3 or B--3	Heat, Sound & Wave Motion	183 to 340
A--4 or B--4	Final for 1st semester	1 to 340
A--5 or B--5	1st part of Electricity & Magnetism	340 to 460
A--6 or B--6	2nd part of Electricity & Modern Physics	460 to 557

Lapp's Iowa Achievement Test

Test No.		Paragraphs in Text Book
A--7 or B--7	Light	557 to 669
A--8 or B--8	Final for 2nd Semester	340 to 669

The coefficient of reliability for each examination as determined by the method of chance halves is .90 to .93.

The administration of the examinations is not difficult. General directions are given in the Manual and explicit directions for each part, together with examples, are given on each examination paper. The directions are entirely adequate as these tests are designed for college level. The time required for each of the mid-semester examinations is forty-five minutes and the final examination, ninety minutes.

A scoring key is furnished for each examination. They are mimeographed and are not spaced to fit the examination. The second part of the examination gives staggered responses which makes it a little difficult to score. No partial credits are allowed and if two answers are given no credit is allowed. In scoring, the parts are weighted as follows: Part one, right minus wrong; Part two, one point for each correct response; Part three, the number of correct responses multiplied by two; and Part four, the number of correct responses multiplied by four. The total score is the sum of the scores on the various parts.

Norms are furnished based on results from seventeen colleges and universities, and given in the form of quartiles for each examination. The author does not state how many cases were included.

The cost of these examinations is $3.00 per hundred copies, plus transportation. Sample copies with manual and scoring sheets may be had for five cents each.

Name of Test:	Peters-Watkins Objective Tests for High School Physics
Authors:	C. J. Peters R. K. Watkins
Publishers:	Authors
Date of Publication:	1930

The authors of these tests are C. J. Peters, formerly supervisor of Science University High School, Columbia, Missouri and R. K. Watkins of the University of Missouri.

The examinations in the aggregate test mechanics, heat, light, sound, magnetism, and electricity. There are seventeen tests in all with two forms of each test. One form purports to measure fundamentals, and the other, application of these principles; form X measuring the fundamentals and form Y the applications. The titles of the tests are as follows: 1. Mechanics, (a) Weights and Measures, (b) Mechanics of Liquids, (c) Mechanics of Gases, (d) Molecular Physics, (e) Force and Motion (f) Work, Power and Energy, (g) Simple Machines, 2. Heat, (a) Themometry and Expansion, (b) Heat and work, (c) Transference, (d) Change of State, 3. Sound, (a) Sound, (b) Musical sound, 4. Light, (a) light, 5. Electricity and Magnetism, (a) Magnetism and Static electricity (b) Effects of current electricity, (c) Electromagnetic Induction (Induced Currents).

The tests are made up of questions, the material for which was taken from the most widely used text books in the state of Missouri. What these texts were, is not told. There is no other information given in regard to the validity, neither is there any reliability coefficient given. The tests are very short in length, the greatest number being 15 and the least, five which would tend to keep the reliability down.

The administration of the test is not very difficult. Adequate directions are given at the beginning o f each test. There are, however, no samples given and confusion is liable to result, because the type of question is mixed. It is composed of simple-recall,

completion and multiple-choice types, mixed at random in all of the examinations. Ruch says of this that it is more systematic and less confusing to segregate the different types of items.[1] The completion type of question is by far the most common.

A scoring key is furnished if ten or more copies are purchased, but the actual scoring of the paper is made difficult by the staggered arrangement of the responses. Each question is arbitrarily assigned a value of ten points making the maximum score on any examination either 50, 100, or 150. Some of the questions consist of several responses and if this is the case the ten points are divided equally among the different answers. These are generally five in number giving each part a credit of two points.

The tests come in a booklet containing all the tests. The pages are perforated so that the separate tests may be torn out. Form X is on one side of the sheet and form Y on the other. There is no time limit stated for the examinations, but the tests are so short that both forms could easily be given in a forty minute period. Norms based on 500 cases are given for each form of the test.

The tests may be purchased from Mr. C. H. Butler, University High School, Columbia, Missouri. The costs of the tests are as follows: Sample set of tests, postpaid 30 cents; packages of ten booklets with manual, norms and keys, $2.50; extra test booklets, ordered in addition to one package of ten booklets, 25 cents each.

1. Ruch, G. M. The Objective or New Type Examination; p.156

Name of Test:	Kilzer-Kirby, An Inventory Test for the Mathematics Needed in High School Physics
Author:	A. Kilzer T. J. Kirby
Publisher:	Public School Publishing Co.
Date of Publication:	1929

This test was prepared as a result of a study made in the Mathematics need in high school physics by R. Kilzer of the University of Wyoming. He was assisted in the preparation of the test by T. J. Kirby of the University of Iowa. The purpose of this test as stated by the authors is: (1) To point out to mathematics teachers those items in their subjects which are useful in high school physics, and to provide a means for testing the pupils on these items; (2) To assist the administration in guiding pupils in their choice of high school physics; (3) To provide an inventory test which may be given by the physics teacher during the first week of the course.

In the preparation of the test a questionnaire was sent to a random sampling of 500 Iowa high schools in order to ascertain the names of the high school physics text books most frequently used. Replies were received from 345 of these and on the basis of these replies, the following text books were chosen: Black and Davis; Carhart and Chute; Dull; Fuller; Brownlee and Baker; and Millikan, Gale, and Pyle. All the problems given in these text books were solved and the processes carefully recorded. On the basis of these, the tenative test was made out and given to 265 pupils and the papers scored carefully. On the basis of these scores the test was revised, some questions omitted, and the remainder arranged in order of difficulty. The revised edition was given to 262 pupils, and on the basis of this data the coefficient of reliability of the test as a whole was found to be $.904 \pm .008$. The probable error of a raw score was found to be 1.4317.

The administration of the test is not difficult. The directions are given on the test paper but no samples are given. There is not much doubt, however, as to what is expected of the pupil and the inclusion of samples would only slightly increase its value. There are ninety questions in all and each correct response scores one. The score is the total of the correct responses. An answer key is provided, spaced to fit the responses. The authors provide a class record sheet with instructions for finding the median, and also provide tentative medians to be used in comparison with the medians found.

The test is divided into two parts. Part one covers simple arithmetic and algebra desirable in physics while part two covers the geometry desirable. The first part of the test is composed of 66 questions and the second part 24, and 40 minutes is allowed for each part.

Tentative norms are given with 262 scores as a basis. They are provided at the tenth, twenty-fifth, fiftieth, seventy-fifth and ninetieth per centiles for each part separately, and for the two parts combined.

The types of questions used are problem, the multiple-choice, and the brief answer types with the great majority being the problem type.

The test is put up in packages, each package containing twenty-five copies of Part I and twenty-five copies of Part II, one direction booklet, and one answer sheet. The price is $1.00 per package. A sample set, including parts I and II, an answer sheet, direction booklet, and a scoring key may be had for 15 cents.

Name of Test: Franzen Test in Applied Physics of Mechanics Heat and Sound[1]
Author: C. G. Franzen
Publisher: Not published

This test is the work of C. G. Franzen of Indiana University. His purpose in formulating this examination was to determine if the physics taught was put to practical use in every day life. The set up of the examination is a matching test. There are forty fundamental principles of physics listed, 20 in mechanics, 10 in heat and 10 in sound. There are also listed on the same page forty applications of the forty fundamental principles. The student is to match these two. To make it slightly more difficult, some of the principles are used more than once and some not at all.

There is no information in regard to validity or reliability but norms are given based on 302 high school students and 86 university students. The report of this work was published in 1927, but it is not published in the form of a test for distribution.

Name of Test: Thorndike's Completion Test in Physics[2]
Author: E. L. Thorndike
Publisher: Not published

These tests have not been published for general sale. They may be found in the reference below. They consist of twelve forms and a practice form. They were made as completion exercises. There were 192 mutilated statements. They were arranged in approximate order of difficulty, sixteen questions to each form. Some of the forms test one phase of physics while others are mixed. The author suggests that the tests will take between 15 and 45 minutes but no exact time is stated. Although the author infers that he has made correlations

1. Franzen, C. G. "An Experiment in the Content of High School Physics" Bulletin of the School of Education, Indiana University 3; p.p.42-57 No. 6, 1927
2. Thorndike, E. L. "Completion Tests in Physics" School Science and Mathematics 22; p.p.637-647 1922

between the scores and achievement in physics he does not give any value. He states that the reliability is as close as for any test of equal length. This article was published in 1922, and probably the tests are not as valid and reliable as tests of later date.

Name of Test:	Chapman's Test in Electricity and Magnetism Sound and Light[1]
Author:	J. Crosby Chapman
Publisher:	No longer published

This test is no longer in print and Rich[2] states that it is no longer of any value. The test was an outcome of several meetings of a club composed of physics teachers of the public schools of Cleveland. The author met with the group to point out the procedure. Each handed in a number of questions. A selection was made, and combined with ten picked out by Chapman. The result was the test in Electricity and Magnetism, Sound and Light. The questions are weighted with respect to their difficulty. There are thirty questions involving for the most part single word answers. There is no reliability given. Norms are given, in the form of percentiles.

Name of Test:	Tilton's Physics Completion Tests[3]
Author:	Harry Whity Tilton
Publisher:	Not published.

These tests were the work of Harry Whity Tilton and were published in 1922. As the name implies they are completion tests and cover the whole field of physics. There are twelve tests. They are not published at the present, but were formerly published by the author at South High School, Pittsburg, Pennsylvania

1. J. Crosby Chapman "Measurement of Physics Information" School Review 27;p.p.748-756 1919
2. Rich, "Available Tests for Results in Teaching Sciences" School Science and Mathematics 26;p.p.845-852
3. Smith, L. & Wright, W. W. "Second Revision of the Bibliography of Educational Measurement," Bulletin of the School of Education, Indiana University 4; No. 2 1927

APPENDIX SECTION II

PHYSICS IA

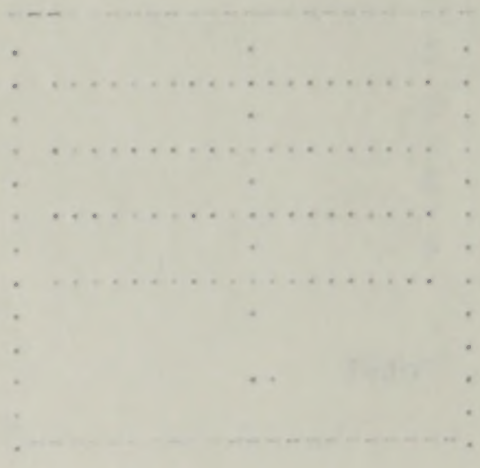
Form A B

Name---------- Date----------

Instructor---------- Period----------

Score

1	
2	
3	
4	
Total	



Below are twenty true-false statements. Some are true, some are false. Read each statement carefully. If you think it is true, place a plus (+) sign in the space at the right-hand side of the page at the end of each question. If it is false, place a zero (o) in this space.

Take each question in order, but do not waste too much time on one part that you do not know. Skip it and go on to the next. Do not guess. If you have any time left, you may go back and work on those you left out.

Study the samples carefully. Samples follow.

Wood is a solid. +

A pint is equal to a liter. o

---

1. Copper is a better conductor than silver. 1.____

2. Like magnetic poles attract each other; unlike poles repel. 2.____

3. When an opaque object which is smaller than the light source casts a shadow, the dark central shadow cone is called the umbra. 3.____

4. The electric charge on a glass rod rubbed with silk is due to a deficiency of electrons. 4.____

5. The coils of an electro-magnet are commonly wound with bare copper wire. 5.____

6. The color of a transparent body is due to the predominant color in the light-waves which it transmits. 6.____

7. A transformer is a device for raising or lowering the voltage of a direct electric current. 7.____

8. When a current is sent through a conductor, the drop in potential is proportional to the resistance of the conductor. 8.____

9. Light waves travel with greater velocity in a dense than in a rare medium. 9.____

10. Light is transmitted in the form of a transverse vibration. 10.____

11. The resonance of a wood-wind instrument is due to forced vibration. 11.____

12. The length of a sound wave of a given frequency varies with the temperature of the air through which it travels. 12.____

13. In a reflecting telescope, the mirror used to produce the real image is a convex mirror. 13.____

14. The intensity of illumination varies inversely as the square of the distance from the luminous source. 14.____

15. A voltmeter should always be connected in series with the circuit whose electrical pressure is to be censured. 15.____

16. The human eye can be focussed to see clearly objects at different distances by changing thecurvature of the lens. 16.____

17. The frequency of vibration of a light wave is the quotient obtained by dividing the velocity by the wave length. 17.____

18. The energy obtainable from a dry cell may be regarded as being produced by the consumption of zinc within the cell. 18.____

19. The electrical resistance of a wire 200 mils in diameter is one-fourth as great as that of a similar wire 100 mils in diameter. 19.___

20. A 50-watt lamp has a greater resistance than a 25-watt lamp of the same voltage. 20.___

There are four possible words given for completing each incomplete statement below. Only one of these words makes the statement true. Read each question carefully, decide which word makes the true completion. Place the number corresponding to that word in the space provided at the right shown in the samples below. If you do not know the answer to any question, go on to the next. Do not hurry as there will be time enough for all to finish.

Sample: At ordinary room temperatures steel is a 1. solid 2. liquid 3. gas 4. vacuum. 1

1. The inventor of the incandescent electric vacuum lamp was (1) Edison (2) Ford (3) Faraday (4) Henry. 1.____

2. Of the following devices the one that the permanent magnet is an essential part of is the (1) Rheostat (2) Induction machine (3) Transformer (4) Telephone receiver. 2.____

3. An ordinary "looking glass" is an example of a (1) plane mirror (2) convex mirror (3) concave mirror (4) plane convex lens. 3.____

4. A magnet will attract pieces of (1) iron (2) copper (3) silver (4) bits of paper. 4.____

5. In the following list of substances the one which is not an insulator is (1) glass (2) carbon (3) paraffin (4) rubber. 5.____

6. The velocity of sound is greatest in (1) vacuum (2) air (3) water (4) steel. 6.____

7. The chemical action of an electric current is utilized in the (1) mazda lamp (2) generator (3) electro-plating process (4) radiant heater. 7.____

8. A blackboard is (1) translucent (2) transparent (3) opaque (4) a kind of mirror. 8.____

9. A leyden jar is a type of (1) electrical battery (2) cell (3) condenser (4) transformer. 9.____

10. A dry cell is not used where a continuous is needed because the dry cell (1) does not produce a steady current (2) produces too strong a current (3) polarizes too quickly (4) initial cost is too great. 10.____

11. A permanent magnet is used in a (1) telegraph sounder (2) compass (3) call bell (4) generator. 11.____

12. When a beam of light strikes perpendicularly upon a sheet of plate glass, the greater portion of the light is (1) diffused (2) reflected (3) transmitted (4) absorbed. 12.____

13. Of the following the color having the longest wave length is (1) red (2) yellow (3) green (4) blue (5) violet. 13.____

14. The resistance of an electrical conductor is measured in (1) ohms (2) amperes (3) volts (4) watts. 14._____

15. Increasing the focal length of a convex lens makes the image of a distant object (1) larger (2) brighter (3) erect (4) smaller. 15._____

16. In the simple astronomical telescope we have (1) two convex lenses (2) two concave lenses (3) one convex and one concave lens (4) two concave mirrors. 16._____

17. The image formed on the retina of the eye is (1) virtual (2) magnified (3) real (4) right side up. 17._____

18. When parallel rays of light are passed through a concave lens, the rays are (1) converged (2) diverged (3) absorbed (4) unchanged in direction. 18._____

19. Two tuning forks having frequencies of 256 and 262 are sounded together. The number of beats heard per second is (1) 131 (2) 128 (3) 24 (4) 6. 19._____

20. The depolarizing agent in the Daniell cell is (1) zinc sulphate (2) manganese dioxide (3) copper sulphate (4) sal ammoniac. 20._____

21. For a person with normal vision the best reading distance is (1) 10 inches (2) 12 inches (3) 15 inches (4) 25 inches. 21._____

22. A black opaque body (1) absorbes (2) reflects (3) transmits (4) refracts the light which strikes it. 22._____

23. When mixed by the additive method, red light plus green gives (1) orange (2) blue (3) yellow (4) white. 23._____

24. The intensity of illumination on a surface varies inversely according to the (1) square of the distance to the source of light (2) candle power of the sources of light (3) square of the candle power of the source of light (4) the distance times the candle power. 24._____

25. The inventor of the cell which produces electricity by chemical action was (1) Galvani (2) Volts (3) Ampere (4) Ohm. 25._____

26. The machine which is used to transform electrical energy into mechanical energy of rotation is called a (1) generator (2) transformer (3) alternator (4) motor. 26._____

27. A skein of green yarn held in red light appears (1) red (2) green (3) blue (4) black. 27._____

28. The propagation of free traveling sound waves is due to (1) longitudinal (2) sympathetic (3) forced (4) transverse vibration. 28._____

29. The experimenter who discovered that a compass needle placed near a wire was deflected by a current in the wire was (1) Oersted (2) Ohm (3) Ampere (4) Faraday. 29._____

30. A 3-cell automobile storage battery has an electromotive force of approximately (1) 6 volts (2) 4.5 volts (3) 2 volts (4) 1.5 volts. 30._____

31. Two coils of 8 ohms resistance each are connected in series. The joint resistance of the group in ohms is (1) 16 (2) 8 (3) 4 (4) 2. 31._____

32. The velocity of light in air is 186000 miles per second and in glass is 124000 miles per second. The index of refraction of glass is (1) 2/3 (2) 1 (3) 3/2 (4) 2. 32._____

33. If 4 dry cells were connected in parrallel the voltage of the battery would be most nearly expressed by (1) 6 (2) 1.5 (3) 4 (4) 3. 33.____

34. A mazda lamp, connected to a 110 volt circuit has a resistance when hot of 220 ohms. The filament current in amperes in (1) o.5 (2) 2 (3) 11 (4) 22. 34.____

35. A sun-bowl heater, connected to a 110 volt circuit takes a current of 5 amperes. The energy consumed in watts is (1) 5 (2) 22 (3) 110 (4) 550. 35.____

36. The primary coil of a transformer carries a current of 2 amperes on a 2200 volt circuit. If the secondary coil is wired to give an E. M. F. of 110 volts, the current in the secondary coil is approximately (1) 10 (2) 20 (3) 40 (4) 80 amperes. 36.____

37. A candle is placed one foot from a photometer screen. The candle power of a lamp which will give equal illumination at a distance of 2 feet from the other side of the screen is (1) 8 (2) 2 (3) 4 (4) 16. 37.____

38. When the air has a temperature of $0^{o}C$, the length of the sound wave sent out be a tuning fork having frequency of 256 is most nearly expressed by the value (1) 1086 ft. (2) 256 ft. (3) 4 ft. (4) 4 in. 38.____

39. A piece of annealed copper wire, 10 mils in diameter has a resistance of 10.4 ohms. The length of the wire is (1) 1 ft. (2) 10 ft. (3) 100 ft. (4) 1000 ft. 39.____

40. Induction coils are used in most automobile ignition systems because (1) they decrease the current flowing from the battery, (2) they increase the voltage in the ignition circuit (3) they give a current only when a spark is desired (4) they prevent too early a spark. 40.____

Below are a number of statements that are incomplete. Fill in the correct word, phrases or number in the space at the right to make the sentence true and complete. SAMPLE--

The common metal which is most strongly attracted by a magnet is _____. 1. Iron

---

1. White light reflected from the smooth surface of a sheet of blue glass will appear._____. 1._____

2. The unit used in measuring the intensity of a source of light is called_____. 2._____

3. The instrument used to measure the pressure maintained in an electrical circuit is called the_____ 3._____

4. If a pith-ball is charged by contact with a charged bulcanite rod and a charged glass rod is brought near, the pith-ball is_____. 4._____

5. In order to develop the greatest possible electromotive force three dry cells should be connected in_____ 5._____

6. The increased loudness caused by holding the handle of a vibrating tuning fork on a table is an example of vibration. 6._____

7. When a string or column of air produces sound by vibrating as a whole, the note it emits is called the_____. 7._____

8. The characteristic of a musical tone which depends on the frequency of vibration is called its_____. 8._____

9. The device commonly used for increasing or decreasing the voltage of an alternating current is called the_____ 9._____

10. When a gold-leaf electroscope is charged by induction, from a charged vulcanite rod, the charge on the electroscope is_____. 10._____

11. The cathode of a dry cell is the terminal at which the current_____the cell. 11._____

12. A transformer used to lower the voltage of the line current for safe household use is called_____transformer. 12._____

13. If a beam of white light is passed through a prism the light is broken up into different colors. This is called _____. 13._____

14. In the camera, a real image is formed by use of a _____lens. 14._____

15. The part of the electric bell that draws the clapper over causing it to hit the bell is an_____. 15._____

16. The rapid falling-off in current strength shown by a single fluid cell on continued use is called_____. 16._____

17. The color in the visible solar spectrum which has the shortest wave length is_____. 17._____

18. The reflector in an automobile headlight is a_____ mirror. 18._____

19. The phenomena caused by the interference between two sound waves of nearly the same length are called_____. 19._____

20. The energy consumed in an electrical circuit is measured in_____. 20._____

21. The optical instrument used for producing spectra is called the_____. 21._____

22. When the light from an incandescent vapor or gas is passed through the prism of a spectroscope it forms a_____ spectrum. 22._____

23. Spectacle lenses used to correct nearsightedness must be ground so as to be_____. 23._____

24. When voltaic cells are to be used supply current continuously the best type to use is a_____fluid cell. 24._____

25. When the current in a transmission line is doubled, the loss in energy due to heating is multiplied by_____ 25._____

26. The index of refraction of crown glass is 1.5; the speed of light in this glass in miles per second is_____. 26._____

27. If the speed of rotation of a generator is increased without changing the field-current, the voltage of the generator is_____. 27._____

28. If an object is 6 inches in height, the height of the image in a plane mirror is_____. 28._____

29. When a beam of light strikes a reflecting body obliquely, the angle betweenthe beam and the normal to the surface is called the angle of_____. 29._____

30. In a sperical convex mirror, the radius of curvature is 12 inches, the focal length is_____. 30._____

31. When an induction coil is connected in series with a telephone transmitter, the line current is_____current. 31._____

32. The theory that light consists of wave fronts projected outward from luminous bodies is called the _____ theory. 32. _____

33. When a piece of soft iron is placed in a magnetic field it acquires the properties of a magnet by a kind of action called _____. 33. _____

34. According to the electron theory, when electrons are removed from a body, that body is said to be _____ charged. 34. _____

35. The ratio of the speed of light in air as compared with the speed of light in a transparent body of different density is called the _____. 35. _____

36. If the current in a wire above a magnetic compass flows from south to north, the north-seeking end of the needle will be deflected toward the _____. 36. _____

37. Two colors which give white when mixed by the additive method are said to be _____. 37. _____

38. A mil foot of wire is a wire of uniform thickness 1 foot long and with a diameter of _____. 38. _____

39. The D. C. Motors used to propel the usual form of electric car are of the _____ type. 39. _____

40. The device by which the external current from a generator is made to flow always in the same direction is called the _____. 40. _____

APPENDIX III

List of Books and Publishers

1. Caldwell, O. W.--The Gary Public Schools, "Science Teaching," General Education Board, 1919. Contains a description of how science teaching is carried on in the Gary Public Schools with samples of a new type test in physics.

2. Holzinger, K. J.--"Statistical Methods for Students in Education," Ginn & Company 1928. A somewhat advanced treatise of statistical methods, but understandable to any one with a knowledge of algebra.

3. Hurd, A. W.--"Cooperative Experimentation in Materials and Methods in Secondary School Physics" Bureau of Publications, Teacher's College, Columbia University. Contains experiments for 1933 with a summary of previous experiments.

4. Kelley, T. L.--"The Interpretation of Educational Measures." The World book Company, 1927. Contains the evaluation of a number of educational tests and elementary statistical methods.

5. McCall, W. A. --"How to Experiment in Education". The MacMillan Co. A treatise on how to set up the conditions and how to conduct the experiment.

6. McCall, W. A.--"How to Measure in Education." The MacMillan Co., 1922. One of the earlier works in educational measurement.

7. Monroe, W. S.--"An Introduction to the Theory of Educational Measurements," Houghton Mifflin Co., 1923. An interesting account of how tests are validated and standardized.

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2. Barthelemess, H. M.--"Reply to Criticism of Tests Requiring Alternative Responses." Journal of Educational Research 6:356-359 1922

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14. Jones, F. J.--"Practise Exercises in Physics" School Review 26:341-348.

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17. McCall, A. W.--"A New Kind of School Examination" Journal of Educational Research 1:34-46 Jan 1920

18. Ozanne, C. E.--"Study of Different Types of Teachers' Tests." School Review 34:54 1926

19. Paterson, G.--"Do old and New Type Examinations Measure Different Mental Functions?" School and Society 24:246-248 1926

20. Pressey, S. L.--"A Simple Apparatus Which Gives Tests and Scores And Teaches." School and Society 23:182 1926

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25. Ruch, G. M. & Meyer, S. H.--"Comparative Merits of Physics Tests" School Science and Mathematics 23:676-680 1931

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APPENDIX IV

LIST OF PUBLISHERS' ADDRESSES

1. Board of Education. Detroit Public School. Detroit, Mich.
2. Bureau of Educational Research and Service, University of Iowa, Iowa City, Iowa.
3. Bureau of Publications, Teachers College, Columbia University, New York City.
4. Daniel Starch, 1374 Massachusetts Ave., Cambridge, Mass.
5. Educational Test Bureau, University and 15th Avenues, S. E., Minneapolis, Minnesota.
6. Ginn and Company, 70 Fifth Ave., New York City.
7. Harlow Publishing Company, Oklahoma City, Oklahoma.
8. Institute of School Experimentation, Teachers College, Columbia University, New York City.
9. MacMillan Company, 60 Fifth Avenue, New York City.
10. C. J. Peters and R. K. Watkins, University High School, Columbia, Missouri.
11. Public School Publishing Company, Bloomington, Illinois.
12. H. W. Tilton, South High School, Pittsburgh, Penn.
13. University Supply and Book Company, 10109 Wilbur Avenue, Cleveland, Ohio.
14. Western State Teachers College, Kalamazoo, Mich.
15. World Book Company, Yonkers, New York.

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